INSTRUCTION MANUAL

BIN C BOOK #23

TYPE 1123-A,-AD

DIGITAL SYNCRONOMETER®

TIME COMPARATOR

U. S. NAVAL SPACE SURVEILLANCE FIELD STATION
P. O. BOX 158
WETUMPKA, ALABAMA 36093
36092

TYPE 1123-A

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GENERAL RADIO COMPANY

A

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Wetumpka, Al.

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WEST CONCORD, MASSACHUSETTS, USA

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• CONDENSED OPERATING INSTRUCTIONS

Referenced paragraphs contain unabridged instructions.

Return PROGRAM switch to OPERATE to prevent accidental disturbance of normal operation.

INITIAL PROCEDURE (paragraph 3.2)

Connect 100-kc drive signal and connect power.
To prevent possible damage in the event more than one number per indicator lights up, turn the PROGRAM switch to SET, turn VISUAL REGISTER switch to offending indicator, and push INITIATE button until only one number is lit.

STARTING CLOCK (paragraph 3.3)

Turn PROGRAM switch to START and push INITIATE button.

SETTING VISUAL REGISTER (paragraph 3.4)

Set digits. Turn PROGRAM switch to SET, turn VISUAL REGISTER switch to desired indicator, and push INITIATE button.

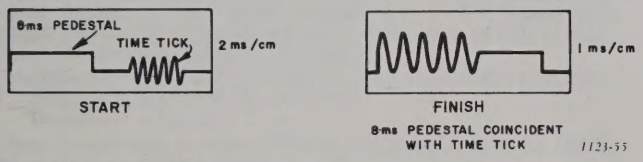
Advance time. Turn PROGRAM switch to SET, turn VISUAL REGISTER switch to OPERATE, and push INITIATE button.

Hold time. Turn VISUAL REGISTER switch fully clockwise.

STOPPING CLOCK (paragraph 3.5)

Turn PROGRAM switch to STOP and push INITIATE button.

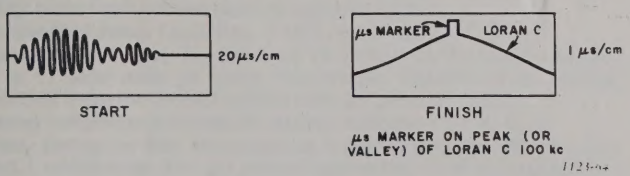
NORMAL-RESOLUTION TIME-COMPARISON (paragraph 3.6)



Use 100, 10, and 1 ms TIME DELAY controls to move time tick to the left and use 100 and 10μs TIME DELAY controls to move 8 ms PEDESTAL to the right. Increase sweep rate to increase resolution.

When the two signals are coincident, the TIME DELAY controls indicate the amount of time the time tick is delayed from the 1 SEC TICK of the Syncronometer.

HIGH-RESOLUTION TIME-COMPARISON (paragraph 3.7)



Make measurement on third or fourth cycle of signal. Set 100 ms TIME DELAY control to X, use 10 and 1 ms and 100 and 10μs TIME DELAY controls to move Loran C pulse to the left, and use 1 and 0.1μs TIME DELAY controls to move μs MARKER to the right. Increase sweep rate to increase resolution.

SYNCHRONIZING (paragraph 3.8.1)

Time-of-arrival coincidence. Make time-comparison measurement then subtract 50μs from TIME DELAY control setting. Set PROGRAM switch to SELF SYNC and push INITIATE button.

Time-of-transmission coincidence (correction for propagation delay). Make time-comparison measurement to determine D_M (D_M = TIME DELAY control setting after time-comparison measurement). Calculate $D_M - D_T$ (D_T = propagation time between standard-time transmitter and receiver). Calculate D_S (D_S= TIME DELAY control setting corrected for propagation time):

If $D_M - D_T \geq 50\mu s$, $D_S = D_M - D_T - 50\mu s$

If $D_M - D_T < 50\mu s$, $D_S = 1{,}000{,}000\mu s + (D_M - D_T) - 50\mu s$

Set TIME DELAY controls to D_S and push INITIATE button.

SLAVING (paragraph 3.8.2)

If the clock is stopped, a signal applied to the START connector will start it regardless of the position of the PROGRAM switch. If the clock is running, the signal will have no effect.

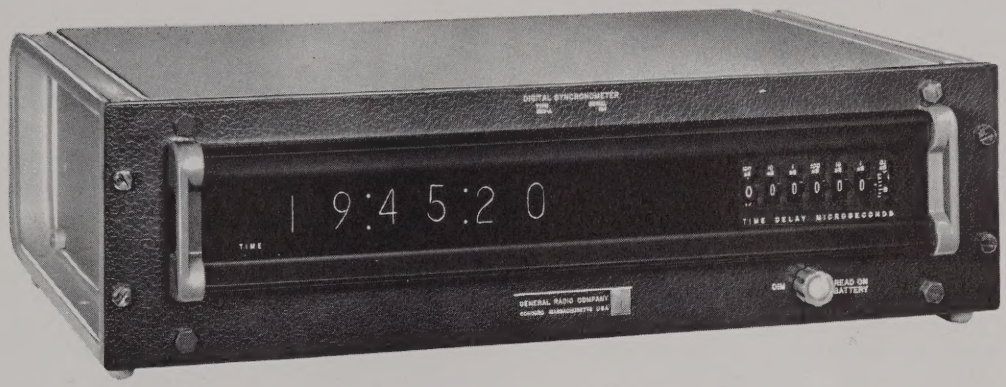
Start Syncronometers simultaneously. Zero all Syncronometers, turn slave PROGRAM switches to OPERATE, turn master PROGRAM switch to START, and push master INITIATE button.

Slave on time of arrival. Zero slave and turn its PROGRAM switch to OPERATE. Turn master PROGRAM switch to START SLAVE, turn its TIME DELAY controls to zero, and push its INITIATE button.

Slave on time of transmission. Zero slave and turn its PROGRAM switch to OPERATE. Turn master PROGRAM switch to START SLAVE, set its TIME DELAY controls to $1 - D_T$ where D_T = cable delay, and push its INITIATE button.

Slave after time of transmission. Zero slave and turn its PROGRAM switch to OPERATE. Turn master PROGRAM switch to START SLAVE, set its TIME DELAY controls for desired delay, and push its INITIATE button.

• SPECIFICATIONS



Input: BNC connectors.
0.5 V at 100 kc/s (sinusoid or square wave).
0.5 V at 1 Mc/s (sinusoid or square wave).
Normally provided from TYPE 1115-B Standard-Frequency Oscillator (1 V into 50 Ω).

Outputs:

Time of Day: From all decades, parallel 1-2-4-2 BCD.
Logical 0: Approx 0.5 V.
Logical 1: Approx +15 V (open circuit).
Logical Line Source Impedance: 100 kΩ.

Timing Pulses: 10 kc/s, 100, 10, 1, and 0.1 c/s are available at output fittings on rear. These outputs are +15-V pulses with approx 100-Ω source impedance and a duty ratio of 0.2. In addition, a 100-kc pulse signal is available.

Oscilloscope Sync Pulse: Settable in 1-ms steps 0.000 to 0.999 s.
Positive pulse, 13 V, $Z_o \equiv 2.2$ kΩ.
Duration, ≈7.5 μs.

Time Comparison Pedestal: Follows oscilloscope sync by 000 to 990 μs (100- and 10-μs steps).
Positive pulse, 10 V from emitter follower.
Duration, ≈8 ms.
$T_r = 0.5$ μs, $T_f = 0.5$ μs.

0.2-μs Marker: 10-V positive pulse, 0.2-μs duration, with approximately 20-ns rise and fall times, and 100-Ω source impedance. This marker is variable in 1-μs steps and a continuous 0- to 1-μs range from 0 to 10 μs after the 8-ms pedestal.

1-s Master Tick Output: Positive pulse from emitter follower.
Amplitude: 10 V. Duration, ≈7.5 ms. $T_r = 2$ μs, $T_f = 2$ μs.

Input Start Pulse: Logical 0 (0 V) to 1 (+15 V) holding for > 10 μs. May come from second clock or external system.

Output Start Pulse: 11 μs, 0 to +15 V, from emitter follower.

Inhibit Pulse Output: Logical 1 (+15 V) to 0 (0 V); lasting approx 9 to 11 time units at lower frequencies, established by setting internal links for desired inhibit rate (no print on carry).

Visual Indication: 6 dimmable digital indicators for h, m, s.

Delay Setting for Time Measurement: 6 digital thumbwheel switches and 1 continuous (0-1 μs) control calibrated in 20-ns increments.

Visual Register Setting: Direct access to all six visual decades, carries inhibited.

Clock Functions: All control and setting functions are operated by a single pushbutton and are normally locked out and covered.

1. Operate: All program controls locked out.

2. Start: Clock will be started by 11-μs start pulse from pushbutton or from external source (BNC connector on rear). Start pulse produced and fed from instrument.

3. Stop: Clock will be stopped and all counting decades from 100 kc/s to 1 c/s will be set to zero by pushbutton. Zero will hold until start command is received.

4. Set: Permits setting visual register. All-visual register carries interrupted; 100-kc to 1-cycle dividers not affected. Selected decade is advanced by 1 count for each push of the initiate pushbutton.

5. Self Sync: Permits synchronizing master tick to within 10 μs of a measured time in another time system, as WWV on UT-2.

6. Start-Slave: Permits setting a second clock from the first. After the initiate button is pushed, a start pulse will be produced when the count reaches the setting of the time-delay switches of the first clock.

Measurement Rate: Switch permits oscilloscope sync at 10-cycle rate rather than the standard one-cycle rate.

Power Required: 90 to 130 or 180 to 260 V, 50 to 60 c/s, 32 W approx. Self-contained, pressure-relief, nickel-cadmium battery for approx 24-hour off-line operation is supplied.

Accessories Supplied: Digital-output plug assembly, TYPE CAP-22 Power Cord, two 24-inch BNC cables, 3 board extenders, spare fuses.

Mechanical Data: Rack-Bench Cabinet

Model	*Width*		*Height*		*Depth*		*Net Weight*		*Shipping Weight*	
	in	*mm*	*in*	*mm*	*in*	*mm*	*lb*	*kg*	*lb*	*kg*
Bench	19	485	6	155	14½	370	30	14	40	18.5
Rack	19	485	5¼	135	12*	305	30	14	40	18.5

* Behind panel.

For a more detailed description, see *General Radio Experimenter*, February 1965.

The Type 1123-AD (formerly Type 1123-AS1) differs from the Type 1123-A only in the characteristics of the time-of-day output lines. An output buffer amplifier has been added to each line to provide 1-2-4-8 coding, faster rise times, and lower output impedances (Logical Line Source Impedance is approximately 10 kΩ).

SECTION 1

INTRODUCTION

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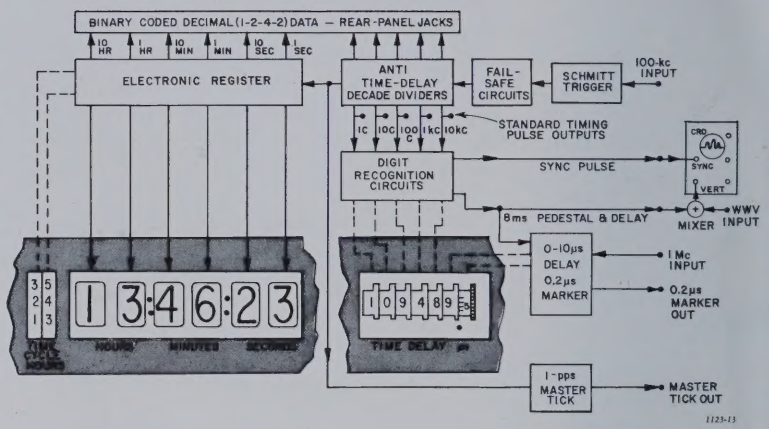
• 1.1 PURPOSE

The Digital Syncronometer® time comparator is a solid-state digital clock for the calibration of frequency and time standards. It provides precise time-of-day information, both visually and in BCD form, and permits accurate comparisons between local standards and the transmission of standard time (WWV, Loran C, etc.). The clock can compare its own time with standard time without disturbance of its internal time. Clock's internal time can be automatically synchronized (within 10 μs) to standard time.

Any number of clocks can be started simultaneously from one location — remote clocks can be started from and synchronized to a local clock (without interruption of local clock). Time also can be transferred from one location to another. (The clock is set at the master station and carried to the remote locations.)

• 1.2 DESCRIPTION

Circuit. Circuit functions in the Syncronometer may be divided into four general parts: starting, timekeeping, synchronizing, and readout.



Starting is accomplished either by a front-panel push-button or by a pulse (from an external source or another Syncronometer). With either method any number of clocks can be started simultaneously, and remote units can be started in synchronism with an operating master clock, without disturbance of the master time indication.

Timekeeping A pulse train derived from the 100-kc input is fed through fail-safe, regenerative-gate circuits. The pulses in the train, 10 microseconds apart, are then divided in five anti-time-delay decade dividers to produce a 1-pps master tick. All timekeeping circuits use silicon transistors operated at low power levels. In the event of power failure, the built-in battery will automatically sustain the timekeeping operation for approximately 24 hours.

Time Comparison and Synchronization. The decade dividers of the timekeeping circuits provide, at output jacks, low-jitter timing pulses at 100 kc/s, 10 kc/s, 1 kc/s, 100 c/s, 10 c/s, 1 c/s, and 0.1 c/s. These signals also operate a five-digit recognition circuit to produce an 8-millisecond pedestal, occurring at 1 pps. This pedestal can be delayed a precise amount of time with respect to the master tick (delay time of 0.00000 through 0.99999 second is selected by front-panel thumbwheels). Pedestal and a sync pulse are provided for comparisons of the master tick with WWV-type transmissions on a CRO screen.

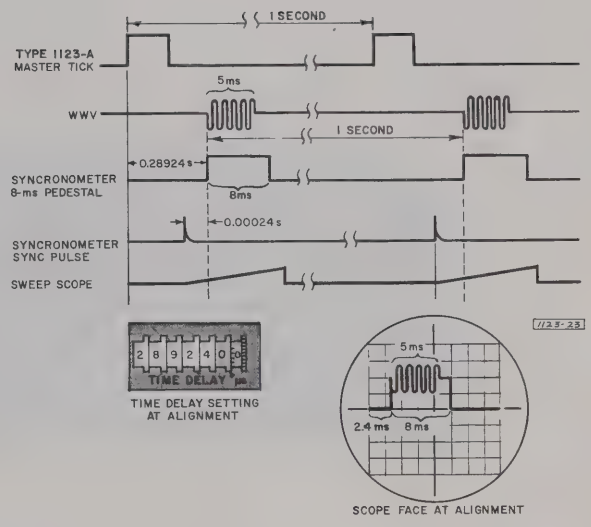
For intercomparisons where greater time resolution is possible (e.g., Loran C), a 1-Mc input is used to drive a delay circuit (0 to 9 microseconds in 1-microsecond steps, 0 to 1 microsecond continuously), which produces a 0.2-microsecond marker controlled by the last two front-panel thumbwheels.

The thumbwheels used in measuring the time interval between the master tick of the Syncronometer and the standard transmissions serve in *synchronizing* the master tick as well.

Readout is both visual and electrical. The clock's 1-pps master ticks are accumulated and displayed in a six-digit bank of illuminated indicators, which can be preset to re-cycle at any number of hours from 1 to 99. The indication of each digit may be changed without carrying to the next digit or interrupting the master tick. An output plug provides BCD data from each digit of the visual bank and from each of the five decade dividers (0.1 second through 10 microseconds). This data is in parallel (1-2-4-2) form, an invaluable aid in providing real-time information for time-dependent measurements.

Time comparison. To determine the precise time relationship of the Digital Syncronometer's master tick to WWV standard timing bursts, both the time transmission and the clock's 8-millisecond pedestal are displayed on a CRO screen. By means of front-panel thumbwheels, successive amounts of delay are introduced until the pedestal is exactly aligned with the WWV bursts. When the delay is determined, the Syncronometer need only be switched to self-sync operation, and the master tick will be shifted to synchronism with the transmission. The sync pulse retains oscilloscope synchronism and keeps the pedestal in view throughout the operation.

Where the characteristics of the standard-time transmission permit greater resolution than that provided by the 8-ms pedestal, the 0.2-μs marker can be used. With this marker, time comparisons with a precision of better than ±20 ns are possible.

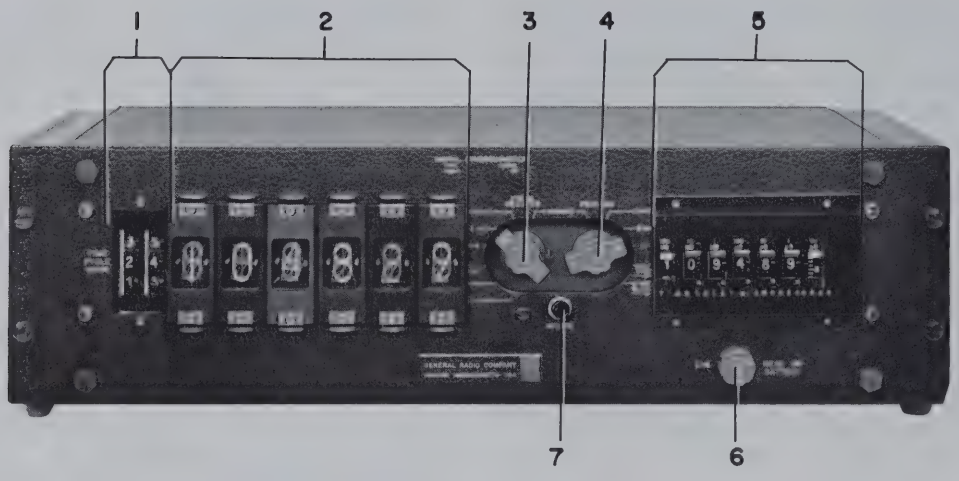


Type 1123-AD (formerly Type 1123-AS1). The Type 1123-AD differs from the Type 1123-A only in the characteristics of the time-of-day output lines. An output buffer amplifier has been added to each line to provide faster risetimes and lower output impedances.

These buffer amplifiers also allow the output code to be changed from 1-2-4-2 to 1-2-4-8 BCD. The Type 1123-AD is normally supplied with the 1-2-4-8 code which can be easily changed to 1-2-4-2 by cutting two wire links on each Decade Divider board.

The buffer amplifiers are automatically turned off on internal battery operation to conserve power. Since the STANDARD FREQUENCIES OUT connectors derive their signals from the buffer amplifiers, these signals are also off during internal battery operation.

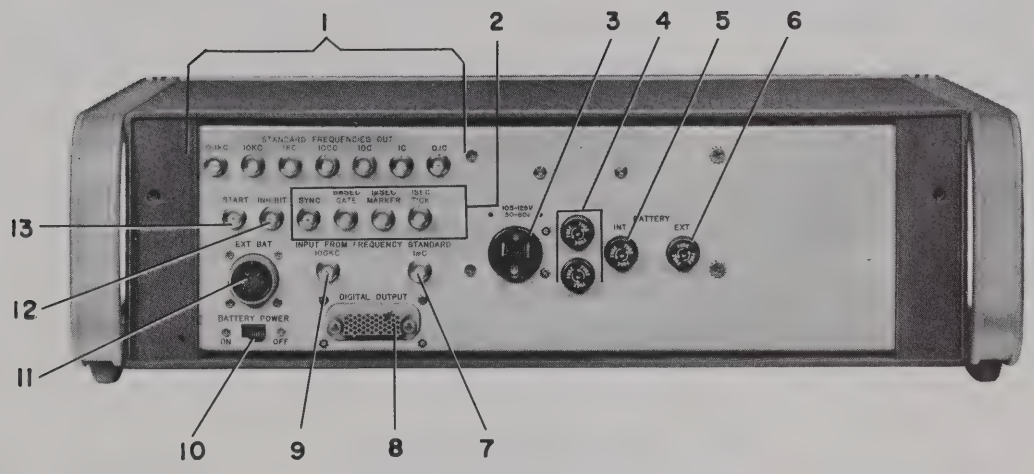
• 1.3 FRONT-PANEL CONTROLS AND INDICATORS



For access to the front-panel controls pull off the protective bezel (held in place by two banana plugs at each end).

1	TIME CYCLE HOURS ..	Two, continuous, thumb-wheel, 10-position, rotary switches. Set the number of hours (from 1 to 99) the clock will register before it resets to zero.
2	TIME (visual register) ..	Six incandescent-lamp-operated indicators. Display, in seconds, minutes, and hours, the time accumulated by the clock.
3	VISUAL REGISTER	Eight-position, rotary switch (last position is momentary and is unmarked). Selects the indicator to be set by the INITIATE button. When the PROGRAM switch is turned to SET, the selected indicator will advance one digit each time the INITIATE button is pushed.
4	PROGRAM	Six-position, rotary switch. Determines operating mode of the instrument; works in conjunction with the INITIATE button. It can be set to start or stop the clock, to set the visual register, to synchronize the clock to *standard time*, or to synchronize another clock. Always return to the OPERATE position to prevent accidental disturbance of normal operation.
5	TIME DELAY.....	Six, continuous, thumb-wheel, 10-position, rotary switches and one potentiometer. Used to determine the time difference, in microseconds, between Syncronometer time and an external time signal.
6	DIM	Seven-position, rotary switch (last position, READ ON BATTERY, is momentary). Adjusts the intensity of the indicators. The READ ON BATTERY position allows the indicators to be read when the instrument is operating from its internal battery.
7	INITIATE	Momentary, push-button switch. It initiates the operation selected by the PROGRAM switch. When the PROGRAM switch is set to OPERATE, the INITIATE button is locked out and has no effect.

• 1.4 REAR-PANEL CONTROLS AND CONNECTORS



1	STANDARD FREQUENCIES OUT	Seven, output BNC connectors. Provide low-jitter, standard timing pulses in decade steps from 0.1 c/s to 100 kc/s.
2	Time-comparison signals	Four, output BNC connectors. Provide signals for time-comparison measurements.
3	Power input	Three-terminal, male connector. For connection to ac line.
4	Line fuses	Two fuses. Protect instrument when it is powered from an ac line.
5	BATTERY, INT	Single fuse. Protects instrument when it is powered from its internal battery.
6	BATTERY, EXT	Single fuse. Protects instrument when it is powered from an external battery or dc power supply.
7	1 Mc INPUT	Input BNC connector. For connection to external 1-Mc time-comparison signal.
8	DIGITAL OUTPUT	52-terminal input/output connector. For connection to printer or other data processing equipment.
9	100 kc INPUT	Input BNC connector. For connection to external 100-kc drive signal.
10	BATTERY POWER	Two-position, slide switch. Connects or disconnects internal battery.
11	EXT BAT	Seven-terminal input/output connector. For connection to external battery. Also contains a print-command and an inhibit pulse connection.
12	INHIBIT	Output BNC connector. Prevents printer or other data processing equipment from accepting information while the Syncronometer is changing state.
13	START	Input/output BNC connector. For connection to another Syncronometer or to other auxiliary equipment. Accepts or provides synchronizing pulses, depending upon setting of PROGRAM switch.

• 1.5 ACCESSORIES SUPPLIED

Quantity	*Description*	*Part Number*
1	Instruction book	1123-0100
1	Power cord, 3-wire, Type CAP-22	4200-9622
2	24-inch, 50-ohm cables with male BNC connectors on each end for connection to rear-panel BNC connectors	8161-1600
2	Fuses, 0.6 A for 115-V operation or 0.3 A for 230-V operation	5330-1100 5330-0800
1	Fuse, 1 A for internal battery	5330-1400
2	Fuses, 2 A for external battery	5330-2000
1	Plug assembly, 7 contact, for EXT BAT connector, consists of: a plug and a clamp	 8420-3630 8420-3620
1	Plug assembly, 52-contact for connection to DIGITAL OUTPUT connector	4220-0128
1	15-pin board extender supplied as a maintenance aid	4215-2016
1	18-pin board extender supplied as a maintenance aid	4215-2019
1	24-pin board extender supplied as a maintenance aid	4215-2025
1	End-frame set (mounted on instrument) for bench model, or Rack-support set for rack model	5310-9632 7863-9632

• 1.6 EQUIPMENT REQUIRED

100-kc DRIVE

The Type 1123-A Digital Syncronometer requires an external 100-kc, 0.5-volt rms, drive signal for operation. Although any precision frequency source may be used, the Type 1115-B Standard-Frequency Oscillator is particularly well suited. The Type 1115-B also supplies a 1-Mc signal, coherent with the 100-kc signal, for high-resolution time-comparison measurements.

• 1.7 EQUIPMENT AVAILABLE

NORMAL-RESOLUTION TIME-COMPARISON MEASUREMENTS

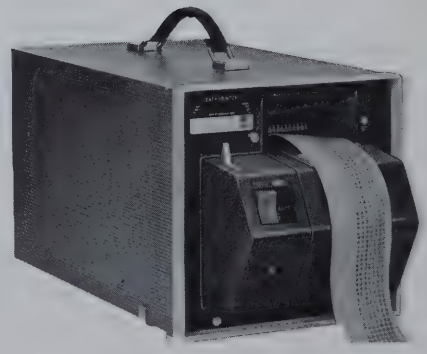
When Syncronometer time is to be compared with *standard-time* transmissions to within 10 μs, an oscilloscope and a receiver for *standard time* are necessary.

HIGH-RESOLUTION TIME-COMPARISON MEASUREMENTS

When Syncronometer time is to be compared with standard-time transmissions to within 20 ns, a 1-Mc signal, coherent with the 100-kc drive signal, is necessary in addition to an oscilloscope and a receiver for standard time. The Type 1115-B Standard Frequency Oscillator provides both the 1-Mc and the 100-kc signals.

DIGITAL RECORDING

The Type 1137-A Data Printer can be used to record the BCD data output of the Syncronometer; resolution is 0.1 second and the printer records the last seven digits (hours, minutes, seconds, and tenths of seconds). Higher-speed readout is available on special order; resolution is 10 microseconds and the printer records all 11 digits (hours, minutes, seconds, milliseconds and microseconds).



SECTION 2

INSTALLATION

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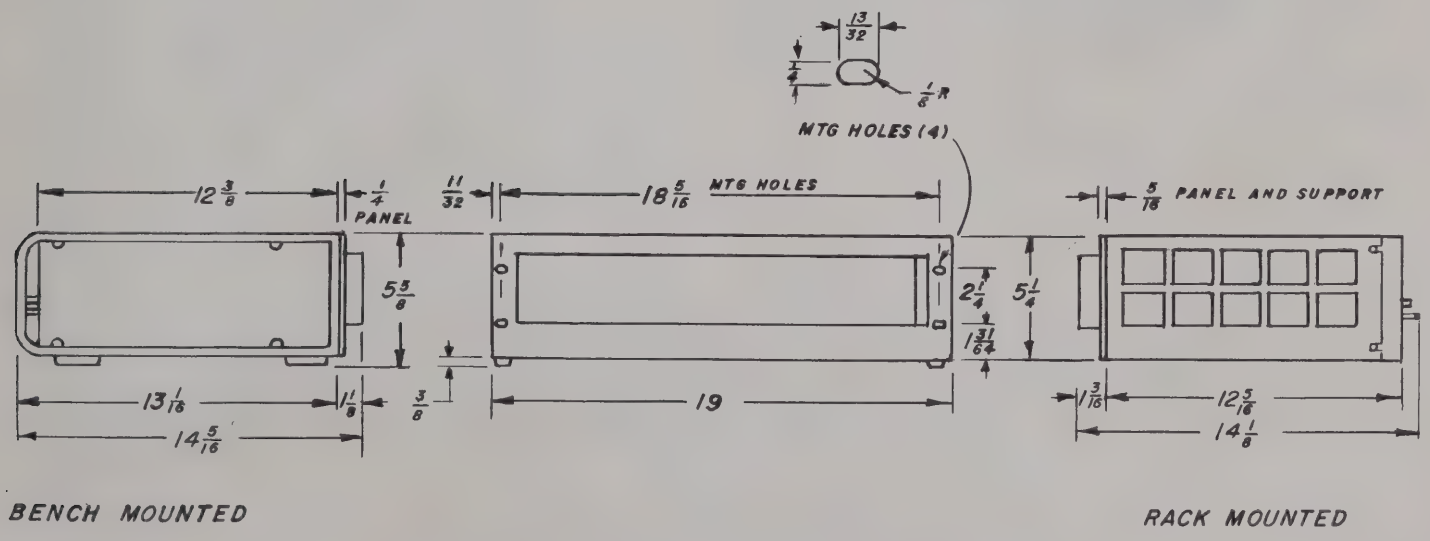


Dimensions for the Type 1123-A Digital Syncronometer

• 2.1 MOUNTING

BENCH/RACK CONVERSION

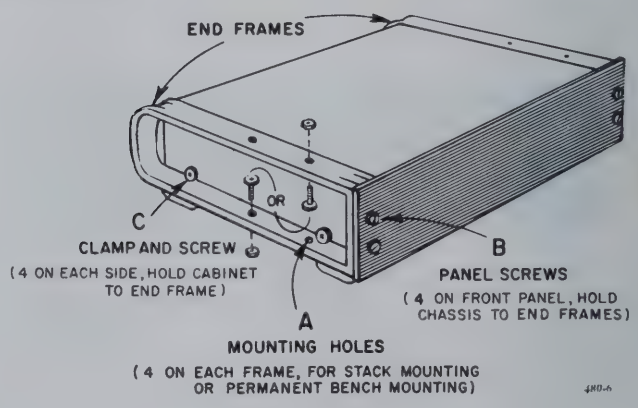
The Type 1123-A Digital Syncronometer is supplied in two models, for bench or relay-rack mounting. Either model may be converted to the other by the installation of a simple conversion set.

Model	*Catalog Number*	*Use*	*Conversion Set*
Bench	1123-9801	For bench mounting and stack mounting	7863-9632 rack-support set converts bench model to rack model.
Rack	1123-9811	For rack mounting in a standard 19-in. relay rack	5310-9632 end-frame set, converts rack model to bench model.

BENCH MOUNTING (bench model)

The Syncronometer normally rests on four rubber feet on top of a bench or shelf. However, holes (A) are provided in each end frame to allow permanent mounting on top of or under a bench or shelf.

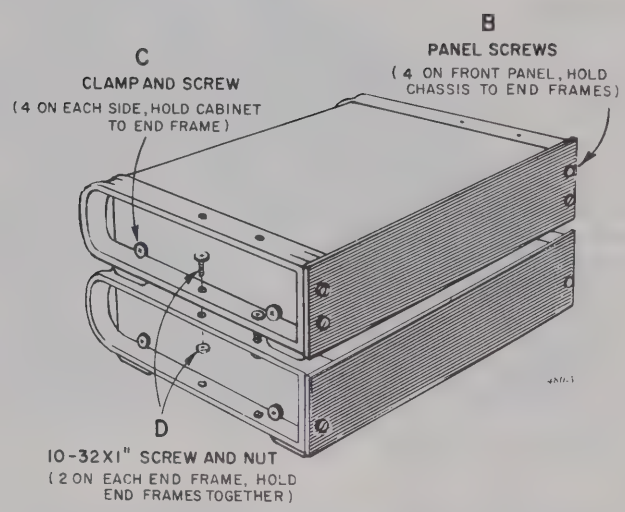
This type of mounting permits either the chassis or the cabinet to be withdrawn independently. To remove the chassis and leave the cabinet mounted, loosen the four panel screws (B) and slide the instrument forward out of the cabinet. To remove the cabinet and leave the chassis mounted, remove the eight clamps and screws (C) and pull the cabinet back off the chassis from the rear of the instrument.



STACK MOUNTING (bench model)

The Syncronometer can be permanently assembled with another rack-bench instrument, such as the Type 1115-B Standard Frequency Oscillator, by bolting the end frames together with four 10-32 one-inch screws and four 10-32 nuts.

This type of mounting permits the chassis of each instrument to be withdrawn independently. To remove the chassis, loosen the four panel screws (B) and slide the instrument forward out of the cabinet.


B
PANEL SCREWS
(4 ON FRONT PANEL, HOLD CHASSIS TO END FRAMES)
C
CLAMP AND SCREW
(4 ON EACH SIDE, HOLD CABINET TO END FRAME)
D
10-32 X 1" SCREW AND NUT
(2 ON EACH END FRAME, HOLD END FRAMES TOGETHER)

RACK MOUNTING (rack model)

To install the Syncronometer in a relay rack, proceed as follows:

a. Attach each support bracket to the rack with two 10-24 binder-head rack screws (E). Use the inside holes on the brackets. Face the bracket lips in.

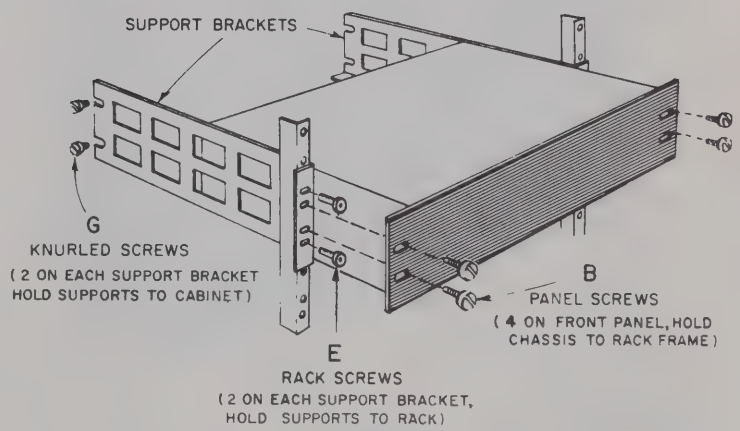
b. Slide the instrument into the brackets as far as it will go.

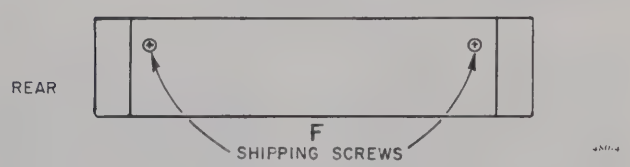
c. Insert the four panel screws with attached washers (B) through the front panel and support brackets and screw them into the rack. The washers are provided to protect the face of the instrument.

d. At the rear of the instrument, remove the two 10-32 binder-head shipping screws that hold the cabinet to the chassis. These are used only for shipment and can be discarded. Two of the four 10-32 knurled screws (G) can be used to secure the cabinet to the chassis, if necessary, for subsequent reshipments.

e. Insert the four knurled screws (G) through the slots in the rear of the support brackets and screw them into the cabinet.

This type of mounting permits either the cabinet or the chassis to be withdrawn independently. To remove the chassis and leave the cabinet mounted, loosen the four panel screws (B) and slide the instrument forward out of the rack. To remove the cabinet and leave the chassis mounted, remove the four knurled screws (G) and pull the cabinet back off the chassis from the rear of the rack.



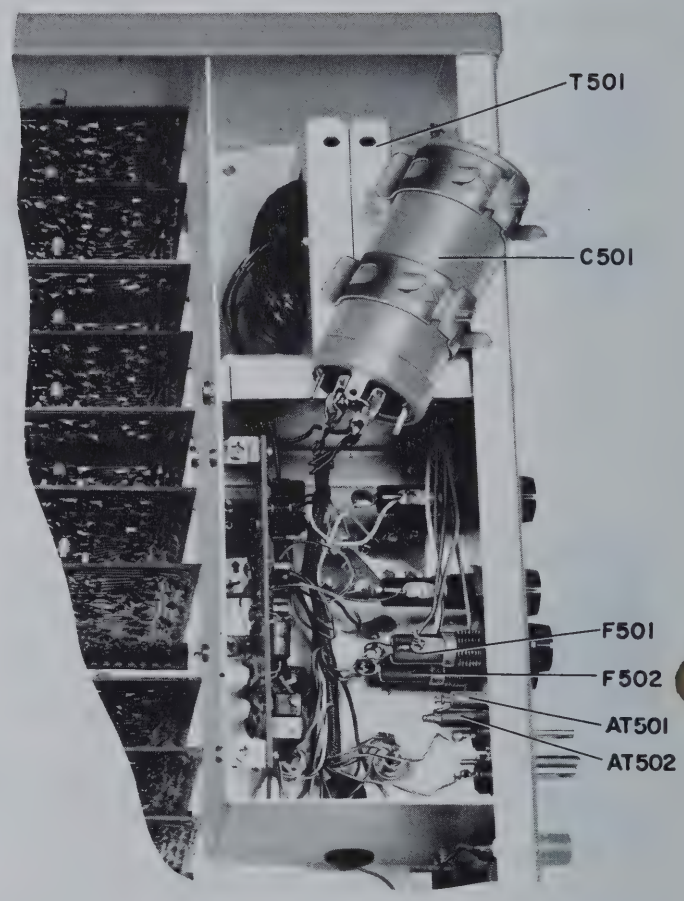


• 2.2 POWER CONNECTION

GENERAL

The Syncronometer can be powered from any one of three sources: ac line, internal battery, or external battery. The power transformer can be wired to accept 50- to 60-cycle line voltages of 105 to 125 volts, 195 to 235 volts, or 210 to 250 volts, at 32 watts. An internal battery automatically takes over in the event of line-voltage failure and will sustain operation for at least 24 hours. A connector is provided to allow the instrument to be operated from an external battery or dc power source of 24 to 32 volts, approximately one ampere.

If ac power, internal battery, and external battery are connected, the instrument will draw power from the source that provides the highest voltage to the regulator circuit. The change-over is made by diodes and is completely continuous.



115-VOLT LINE

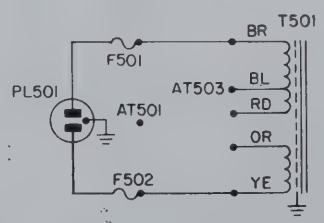
Power required is 105 to 125 V, 50 to 60 c/s, 32 W. No name plate is used, as the input-line-voltage data is silk-screened on the rear of the instrument above the power input connector. For transformer wiring, connect the orange lead to F501 and the red lead to F502. Fuses for F501 and F502 are 0.6A, part number 5330-1100, each.

215-VOLT LINE

Power required is 195 to 235 V, 50 to 60 c/s, 32 W. A name plate for 215-V operation is used, part number 5590-1668. It attaches to the rear of instrument above the power input connector, by means of two 4-40 x 3/16-in. screws with attached lockwashers, part number 7090-4030, each. For transformer wiring, connect the orange lead to AT503 and the red lead to AT501. Fuses for F501 and F502 are 0.3 A, part number 5330-0800, each.

230-VOLT LINE

Power required is 210 to 250 V, 50 to 60 c/s, 32 W. An input plate for 230-V operation is used, part number 5590-1660. It attaches to the rear of the instrument, above the power input connector, by means of two 4-40 x 3/16-in. screws with attached lockwashers, part number 7090-4030, each. For transformer wiring, connect the orange lead and the red lead to AT501. Fuses for F501 and F502 are 0.3 A, part number 5330-0800, each.



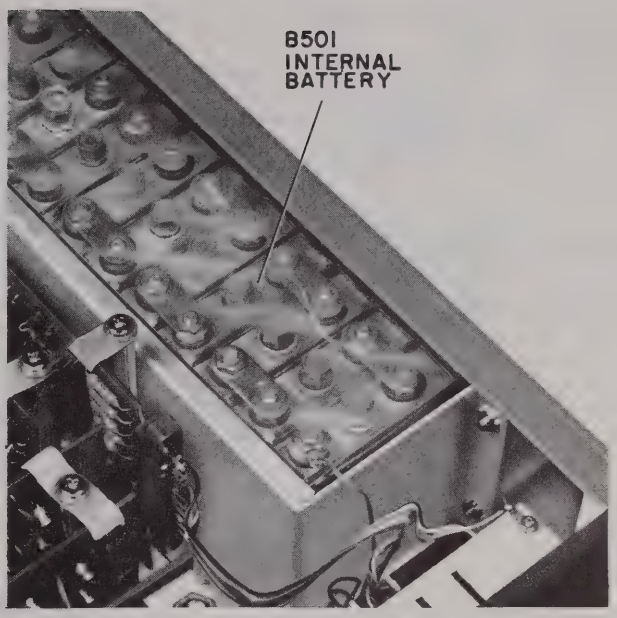
115 V : CONNECT OR TO F501 AND RD TO F502
215 V : CONNECT OR TO AT503 AND RD TO AT501
230V : CONNECT OR TO AT501 AND RD TO AT501

INTERNAL BATTERY

A self-contained battery can sustain Syncronometer operation for at least 24 hours. This battery takes over automatically when the line voltage fails if the rear-mounted BATTERY POWER slide-switch is in the ON position. A separate fuse (F503, 1A) protects the instrument when it is operating from the internal battery. During normal operation, a battery charger provides a trickle charge to maintain the battery at full capacity.

The internal battery is a 16-volt, 12-cell, nickel-cadmium type with a 4½ ampere-hour capacity. Each cell contains a 60-psi pressure-relief valve to prevent an explosion if the cell develops excessive internal gas (excessive gas could develop during charge if the cell were first discharged to such an extent that polarity reversal occurred). Damage to the instrument is prevented, even if a release valve opens, because the cells contain no free electrolyte and because the top of the battery is enclosed in a plastic cover.

The charge-discharge duty ratio of the battery is approximately 30%; i.e., it takes twice as long to charge it as it does to discharge it.

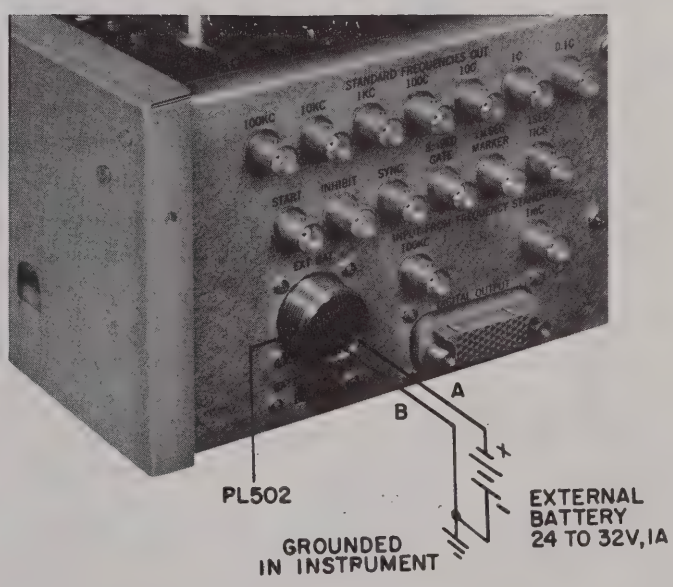


EXTERNAL BATTERY

The Syncronometer can be operated from an external 24 to 32 volt dc power source. This may be desirable if the instrument is to be shipped while operating and will be in transit longer than the normal 24 hours covered by the internal battery, or if the normal ac-line voltage is out of service or not available, or if it is necessary to isolate the Syncronometer from the line for some reason.

The external source (batteries or dc power supply) connects to a seven-contact plug, which mates with the EXT BAT connector, PL502, mounted on the rear of the instrument. The current drawn by the Syncronometer from the external source is about one ampere. A separate fuse (F504,2A) protects the instrument when it is operating from an external source.

If the line voltage is connected, the external source operates the same as the internal battery; i.e., it takes over if the line voltage fails. If the line voltage is not connected, the Syncronometer operates from the external source exclusively. If the BATTERY POWER switch is ON, the internal battery is in the circuit, is being charged by the external source, and will take over if the external source fails.



• 2.3 100-kc DRIVE SIGNAL CONNECTION

The Type 1123-A Digital Syncronometer requires an external 100-kc drive signal for operation. It connects to the 100-kc female BNC connector, J601, on the rear of the instrument. The signal required is 0.5 volt, rms, into 50 ohms and can be supplied by a Type 1115-B Standard Frequency Oscillator, which provides an output of 1 volt, rms, into 50 ohms. The accuracy of the Syncronometer depends on the accuracy of the 100-kc drive signal.

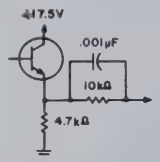
• 2.4 1-Mc TIME-COMPARISON SIGNAL CONNECTION

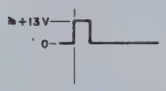
In addition to a 100-kc drive signal, the Type 1123-A Digital Syncronometer requires an external 1-Mc signal, coherent with the 100-kc signal, for high-resolution time-comparison measurements (the 1-Mc signal is not required for normal-resolution measurements). It connects to the 1-Mc female BNC connector, J902, on the rear of the instrument. The signal required is 0.5 volt, rms, into 50 ohms and can be supplied by the Type 1115-B Standard Frequency Oscillator, which provides an output of 1 volt, rms, into 50 ohms.

● 2.5 REAR CONNECTORS, TYPICAL CHARACTERISTICS

1 SEC TICK J802

BNC

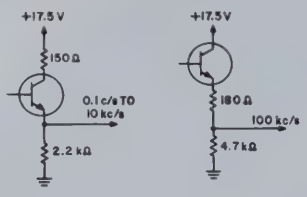


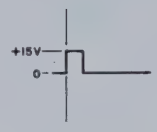


CONNECTOR	OUTPUT CIRCUIT	WAVEFORM	REPETITION RATE	DURATION	RISE TIME	FALL TIME	Z
1 SEC TICK J802			1c/s	4 to 6ms	2μs	2μs	10k

STANDARD FREQUENCIES OUT

BNC



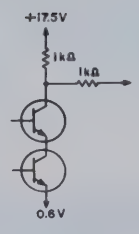


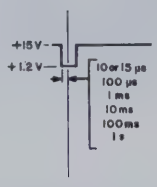
100kc/s	J602	6 to 7μs	0.2μs	2μs	5k
10kc/s	J101	16 to 22μs	2μs	0.5μs	>100Ω
1kc/s	J102	190 to 210μs	3μs	2μs	>100Ω
100c/s	J103	2ms	3μs	2μs	>100Ω
10c/s	J104	20ms	3μs	2μs	>100Ω
1c/s	J105	200ms	3μs	2μs	>100Ω
0.1c/s	J106	2s	3μs	2μs	>100Ω

Duty ratio is 0.4 for 100-kc signal, 0.2 for others.

INHIBIT J651

BNC



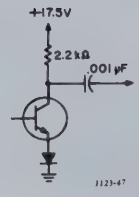


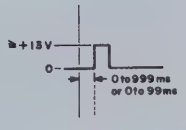
	connect AT1 to:	AT2 to:		-trans	+trans	
10kc/s	AT3	AT9	20 or 30μs			
1kc/s	AT4	AT3	200μs			
100c/s	AT5	AT4	2ms	0.3μs	0.2μs	2k
10c/s	AT6	AT5	20ms			
1c/s	AT7	AT6	200ms			
0.1c/s	AT8	AT7	2s			

INHIBIT rate is set by two internal jumpers on Inhibit board and is normally set for 1c/s. INHIBIT pulse brackets divider carry pulses (count transitions) and indicates time-of-day information is changing and should not be used. Pulse duration is 20% of repetition period.

SYNC J803

BNC



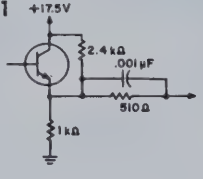


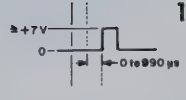
1 or 10c/s — 5 to 9μs — 1.5μs — 1.5μs — 2.2k

Leading edge of SYNC pulse is delayed with respect to leading edge of 1 SEC TICK by the 100ms, 10ms, and 1ms TIME DELAY controls. With 100ms control setting of X, repetition rate is 10c/s and delay is 0 to 99ms, with any other 100ms control setting, repetition rate is 1c/s and delay is 0 to 999ms.

8ms PEDESTAL J801

BNC



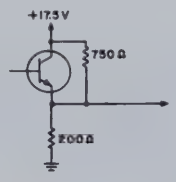


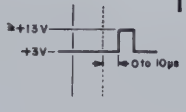
1 or 10c/s — 6 to 10ms — 0.5μs — 0.5μs — 1k

Leading edge of 8ms PEDESTAL is delayed with respect to leading edge of SYNC pulse by the 100μs and 10μs TIME DELAY controls.

μs MARKER J901

BNC



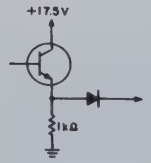


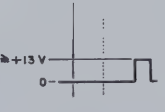
1 or 10c/s — 0.2μs — 0.02μs — 0.02μs — 100Ω

Leading edge of μs MARKER is delayed with respect to leading edge of 8ms PEDESTAL by the 1μs and 0.1μs TIME DELAY controls. To increase duration to ≈1μs, increase C921 to 100pF. To increase duration to >1μs, increase C921 to 180pF and increase C920.

START J701

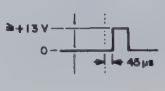
BNC





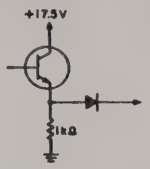
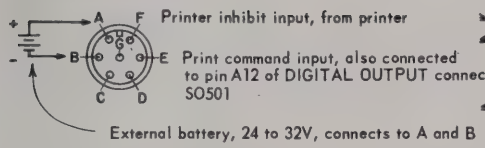
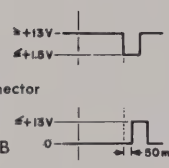
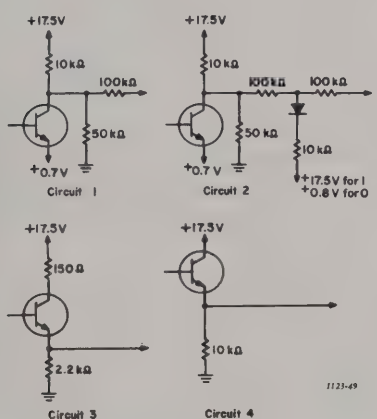
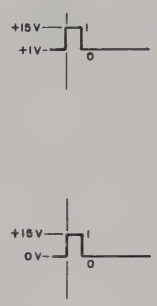
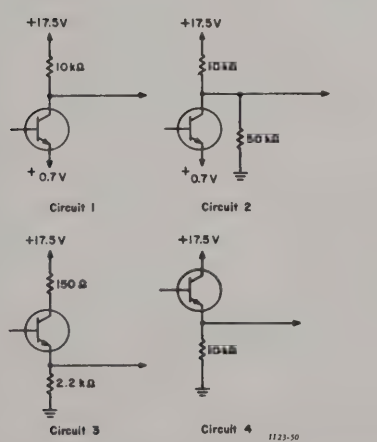
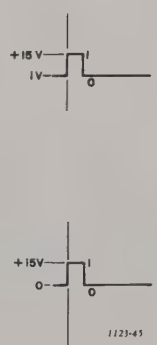
START PROGRAM — 11 to 14μs — <1μs — <1μs — 1k

When PROGRAM switch is set to START, START pulse occurs when INITIATE button is pushed.



SELF SYNC PROGRAM — 11 to 14μs — <1μs — <1μs — 1k

When PROGRAM switch is set to SELF SYNC and INITIATE button is pushed, START pulse occurs 45μs after 8ms PEDESTAL.

CONNECTOR	OUTPUT CIRCUIT	WAVEFORM	REPETITION RATE	DURATION	RISE TIME	FALL TIME	Z
START J701 continued							
BNC			**START SLAVE PROGRAM**	11 to 14μs	<1μs	<1μs	1k
			When PROGRAM switch is set to START SLAVE and INITIATE button is pushed, START pulse occurs coincident with 8ms PEDESTAL.				
			START INPUT	11 to 14μs	1μs	1μs	1k
			START connector is an input/output connector. A start signal applied to J701 will start clock regardless of PROGRAM switch setting. If clock is already started, pulse will have no effect.				
EXT BAT PL502							
A F Printer inhibit input, from printer B E Print command input, also connected to pin A12 of DIGITAL OUTPUT connector SO501 C D External battery, 24 to 32V, connects to A and B			**PRINT COMMAND**	≥100ms			
			Signal required for Type 1137-A Data Printer shown indicates printing operation.				
			PRINTER INHIBIT	200ms			
			Signal from Type 1137-A Data Printer shown. Indicates printing operation in process and data to printer should not change.				
DIGITAL OUTPUT SO501							
TYPE 1123-A			**CIRCUIT 1**	10μs	10μs		100k
			Used for lines 1, 2, and 3 except 10s and 10m line 3.				
			CIRCUIT 2	10μs	10μs		200k
			Used for 10s and 10m line 3, and 1m, 1h, and 10h line 4.				
			CIRCUIT 3	3μs	2μs		>100Ω
			Used for line 4 except 10μs and 10s through 10h.				
			CIRCUIT 4				
			Used only for 10μs line 4.				
			The Type 1123-A is normally supplied with 1-2-4-2 weighting. Can be converted to 1-2-4-8 by changing Decade and Scale-of-6 Divider boards.				
TYPE 1123-AD			**CIRCUIT 1**	2μs	2μs		10k
			Used for lines 1, 2, and 3 except 10s and 10m line 3.				
			CIRCUIT 2	2μs	0.5μs		10k
			Used for 10s and 10m line 3, and 1m, 1h, and 10h line 4.				
			CIRCUIT 3	3μs	2μs		>100Ω
			Used for line 4 except 10μs and 10s through 10h.				
			CIRCUIT 4	2μs	0,5μs		10k
			Used only for 10μs line 4.				
			The Type 1123-AD1 is normally supplied with 1-2-4-8 weighting. Can be converted to 1-2-4-2 by removing two links (CC and DD) on each of the nine Decade Divider boards.				

	10h	h 10m	m 10s	s 100ms	10ms ms	100μs 10μs	
LINE 1	A2	A4	A6	A8	A10	A12	PRINT COMMAND
	B1	B3	B5	B7	B9	B11	B13-INHIBIT
2	C2	C4	C6	C8	C10	C12	BIAS
	D1	D3	D5	D7	D9	D11	D13
3	E2	E4	E6	E8	E10	E12	
	F1	F3	F5	F7	F9	F11	F13
4	G2	G4	G6	G8	G10	G12	
	H1	H3	H5	H7	H9	H11	H13-GROUND

Line 1, 2, 3 Use circuit 1 except 10s and 10m line 3 use circuit 2

Line 4 Use circuit 3 except 10μs uses circuit 4, 10s and 10m are grounded, and 1m, 1h, and 10h use circuit 2

• 2.6 TYPE 1137-A DATA PRINTER CONNECTIONS

The Type 1137-A Data Printer will print time-of-day information at a maximum rate of three prints per second. To prevent recording of erroneous data, the information must be presented so the printer does not accept data while the data is changing in the clock and so a print command is not issued while the printer is setting up for a printing operation, printing, or recovering from a printing operation.

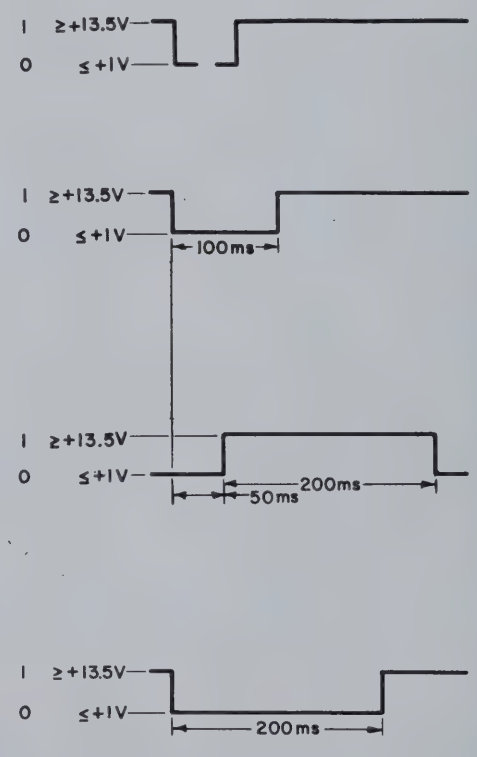
SIGNALS

Time-of-day. Time-of-day data is four-line, 1-2-4-2 BCD from the Type 1123-A and four-line, 1-2-4-8 BCD from the Type 1123-AS1 (can be converted to 1-2-4-2). The binary 1 is a level of +13.5 volts or greater and the binary 0 is a level of +1 volt or less. Signal connection is from the DIGITAL OUTPUT connector, SO501.

Print command The print command to the printer must be a 1-to-0 transition. The signal must remain at the 0 level for at least 100 ms to allow the printer to set up and print and must return to the 1 level at least 15 ms before the next print command to allow the printer to recover. Signal connection is pin A12 and B13 of the DIGITAL OUTPUT connector, SO501, and pin E of the EXT BAT connector, PL502.

Printer inhibit An inhibit signal is available from the printer to indicate that a print cycle has begun and the data input should not change during this time. The signal is a contact closure to the reference bias voltage (+13.5 V), and occurs 50 ms after receipt of a print command and lasts no longer than 200ms. Signal connector is pin F of the EXT BAT connector, PL502. and pin G12 of the DIGITAL OUTPUT connector, SO501.

Clock inhibit . An INHIBIT signal is available from the Syncronometer to indicate that the time-of-day information from the clock is changing and should not be used. The signal occurs at a 1-cycle rate and lasts 200 ms (can be changed in decade steps from 0.1 c/s to 10 kc/s; duration is 20% of repetion period). Signal connection is pin B13 of the DIGITAL OUTPUT connector, SO501, or the INHIBIT connector, J651.

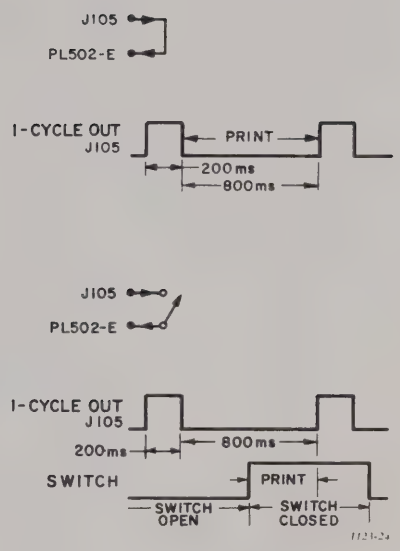


METHODS

All methods require an 1137-0220 cable between the DIGITAL OUTPUT connector of the Syncronometer and the rear connectors of the printer. The maximum resolution is 0.1 second without a parallel-entry storage device (available on special order, resolution is 10 μs).

1-second recurrent print, 1-second resolution Connect the 1-cycle STANDARD FREQUENCY OUT connector, J105, to pin E of the EXT BAT connector, PL502. The 1-cycle STANDARD FREQUENCY pulse interval is used as the print command signal. Its 800-ms 0 level is more than sufficient to allow the printer to complete a printing operation and its 200-ms 1 level is more than sufficient to allow the printer to recover. The printer prints every second with a resolution of one second.

A normally open switch can be added to allow single prints. It is closed until a printing operation is completed and then it is released. This method is not perfectly effective because of the possibility the switch may be closed in relation to the 1-cycle STANDARD FREQUENCY so as not to allow a full 100-ms print time.



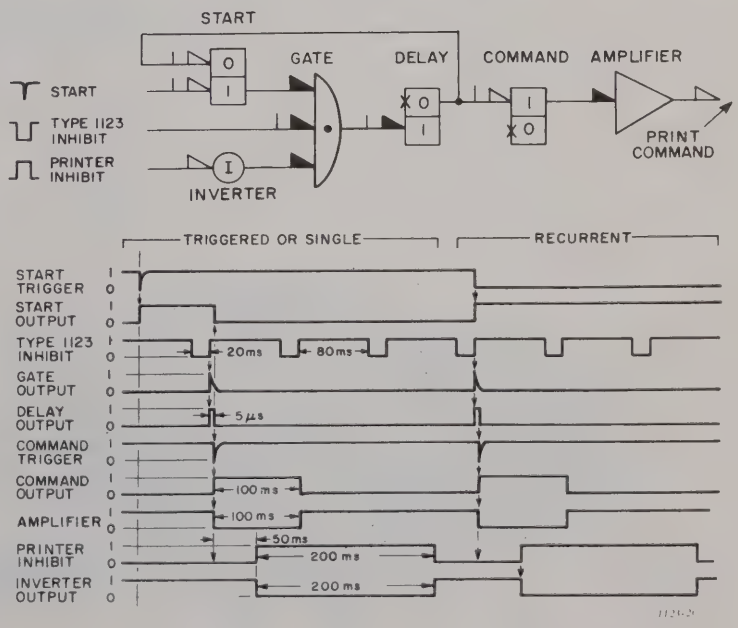
Triggered, single, or recurrent print; 0.1-second resolution. A 1-to-0 transition start trigger, initiated by any desired source, sets the start flip-flop to the 1 state. The output of the flip-flop is dc coupled to a three-input and gate. The 1-level output of the flip-flop constitutes one enabling input to the gate.

A second enabling input is provided by the printer inhibit signal through an inverter. The third, and last, enabling input is derived from the trailing edge of the Type 1123 inhibit signal. This 0-to-1 transition appears as the gate output signal and is used to trigger the delay circuit, a 5μs monostable multivibrator.

The trailing edge of the delay circuit output is differentiated and is used as the 1-to-0 transition command trigger. The command trigger resets the start flip-flop back to the 0 state and sets the command circuit to the 1 state. The command circuit is a 100-ms monostable multivibrator whose output is inverted by an amplifier stage and applied to the printer as the print command signal.

Fifty ms after receipt of a print command signal, the printer generates a 1-level printer inhibit signal. This signal is inverted, as explained above, but now appears as a 0-level input to the gate which disables the gate long enough for the printer to complete a printing operation (about 200 ms).

For single prints, the start trigger is generated by a manually-operated push-button switch. For recurrent prints (3 to 4 prints per second, maximum) the start trigger is replaced by a 0-level voltage to hold the start circuit in the 1 state. The print command is then initiated solely by the printer inhibit and 1123 inhibit signals.



SECTION 3

OPERATING PROCEDURE

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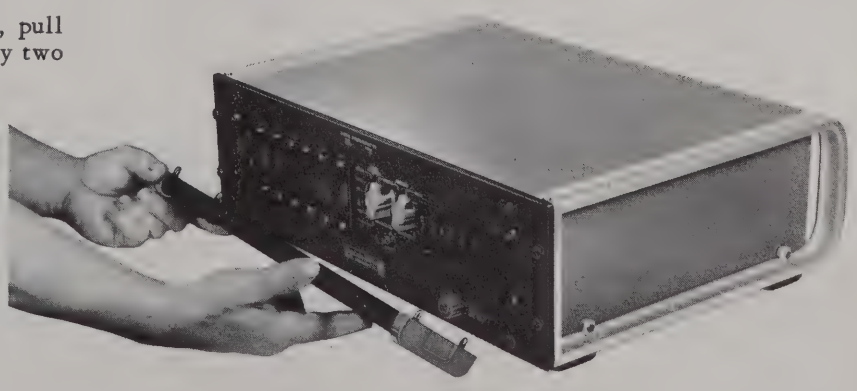
● 3.1 ACCESS TO CONTROLS

For access to the front-panel controls, pull off the protective bezel (held in place by two banana plugs at each end).



● 3.2 INITIAL PROCEDURE (POWER FIRST APPLIED)

a. Turn the PROGRAM switch to SET and check that the 100-kc drive signal is connected.

b. Connect power and check that only one number per indicator is lit.

When power is first applied, more than one number per indicator may light up. To prevent possible damage to the indicator circuits in this event, turn the PROGRAM switch to SET, set the VISUAL REGISTER switch to the offending indicator, and push the INITIATE button to advance the count until only one number is lit.

c. If operation in the event of power-line failure is desired, set the BATTERY POWER switch, on the rear of the instrument, to ON.

When the BATTERY POWER switch is ON, the internal battery in the instrument automatically supplies power for at least 24 hours in the event of power-line failure. The indicators are turned off, however, to conserve power. To turn them on, turn the DIM control fully clockwise to the spring-return READ ON BATTERY position.

After completing any desired operation with the Syncronometer, return the PROGRAM switch to OPERATE. In this position, all functions and the INITIATE button are locked out to prevent accidental disturbance of normal operation.

● 3.3 STARTING CLOCK

a. Turn the PROGRAM switch to START.

b. Push the INITIATE button to start the clock.

The clock will begin counting as evidenced from the indicators. It does not start from zero however, and if the visual register read 11h 31m 17s before the clock was started, it will read 11h 31m 18s one second after it is started.

If it is desired to start the clock from zero, turn the PROGRAM switch to STOP and push the INITIATE button. This sets the first five decades to zero. Then turn the PROGRAM switch to SET and zero the visual register manually by turning the VISUAL REGISTER switch to each indicator position and pushing the INITIATE button until all indicators read zero.

• 3.4 SETTING VISUAL REGISTER

3.4.1 SET DIGITS

a. Turn the PROGRAM switch to SET.

b. Turn the VISUAL REGISTER switch to the indicator whose digit is to be changed.

c. Push the INITIATE button to advance the *indicator* count.

In the set-digits mode, the instrument counts normally until the INITIATE button is pushed; i.e., the indicators accumulate count and, when full, return to zero and advance the count on the next indicator (count, cycle, and carry).

After the first time the INITIATE button is pushed, the selected indicator will cycle but will not carry due to a carry disconnect circuit. Thus, the only indicator affected in the set-digits mode (after the first initiate pulse) is the indicator selected by the VISUAL REGISTER switch. For example, if the count is 11h 58m 59s and the VISUAL REGISTER switch is set to MIN, the count will be 11h 59m 59s after the first push of the INITIATE button and 11h 50m 59s after the second push. If the first count is 11h 59m 59s, it will be 12h 00m 59s after the first push since the carry disconnect circuit is not enabled until *after* the first initiate pulse.

3.4.2 ADVANCE TIME

a. Turn PROGRAM switch to SET.

b. Turn VISUAL REGISTER switch to OPERATE.

c. Push INITIATE button to advance *register* count by one second.

In the advance-time mode, the carry disconnect circuit is switched out and, although the INITIATE button directly affects only the seconds indicator, more than one indicator may change count because normal carry operation is maintained. For example, if the count is 11h 59m 59s, it will change to 12h 00m 00s after the INITIATE button is pushed.

3.4.3 HOLD TIME

a. The PROGRAM switch can be turned to any position.

b. Turn the VISUAL REGISTER switch fully clockwise (spring-return position) to hold time (stop indicators from changing count).

In the hold-time mode, the visual register stops counting. Thus, if the Syncronometer registers 11h 59m 59s and the correct time is 11h 59m 55s, the visual register can be stopped for four seconds to allow the correct time to catch up to it.

• 3.5 STOPPING CLOCK

a. Turn the PROGRAM switch to STOP.

b. The VISUAL REGISTER switch can be set to any position.

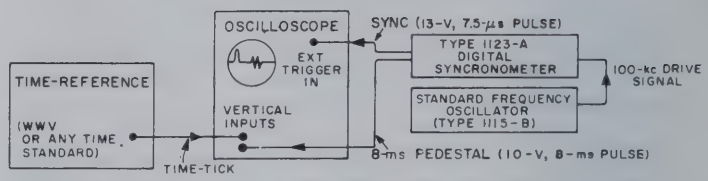
c. Push the INITIATE button to stop the clock.

When the clock is stopped, the first five decades (but not the visual register) cycle to zero. This ensures that the clock starts from zero when it is to be started in synchronism with another signal.

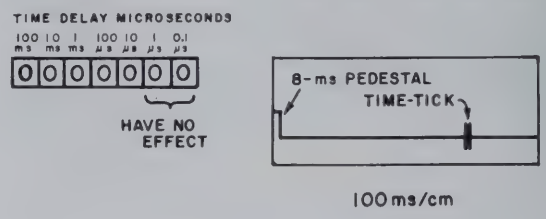
• 3.6 NORMAL-RESOLUTION TIME-COMPARISON MEASUREMENTS

The resolution of this technique is 10 μs, more than adequate for use with WWV-type standard-time transmissions since the instability of the received signals greatly exceeds 10 μs.

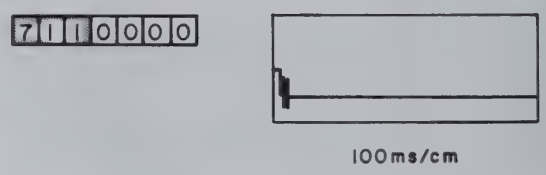
a. Connect the equipment as shown. The 8 ms PEDESTAL of the Syncronometer and the output of the receiver must be added (an oscilloscope with a differential input is excellent for this purpose).



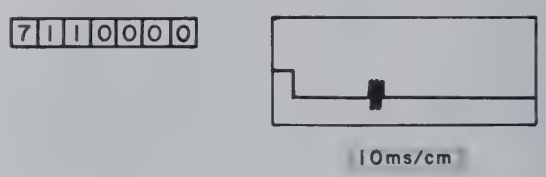
b. Set the TIME DELAY controls to zero and set the oscilloscope sweep rate to 100 ms/cm. The 1 μs and 0.1 μs controls have no effect and can be set anywhere.



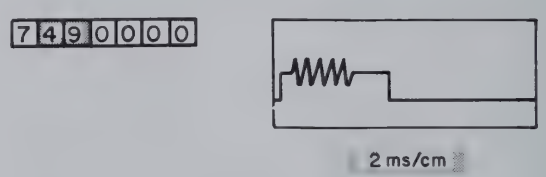
c. Increase the delay with the ms TIME DELAY controls to move the time tick left towards the 8 ms PEDESTAL.



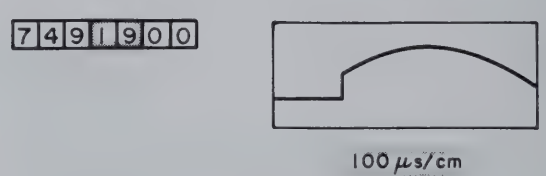
d. Increase the oscilloscope sweep rate to increase the resolution.



e. Increase the delay to superimpose the time tick on the 8 ms PEDESTAL. Increase the oscilloscope sweep rate to increase the resolution.



f. Increase the delay with the 100 μs and 10 μs TIME DELAY controls to move the 8 ms PEDESTAL to the right until the leading edges of the time tick and the 8 ms PEDESTAL coincide exactly. Increase the oscilloscope sweep rate to increase the resolution.



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The final setting of the TIME DELAY controls is the amount of time the received time tick is delayed from the 1 SEC TICK of the Syncronometer.

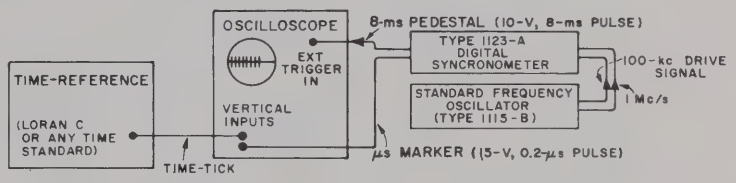
It is not necessary to start the measurement with an oscilloscope sweep rate as slow as 100 ms/cm. The slow sweep rate was chosen for this example to ensure the time tick appeared on the display. Nor is it necessary to preset all of the TIME DELAY controls to zero. This was done here to ensure delay was always added and it was unnecessary to hunt back and forth for the time tick.

● 3.7 HIGH-RESOLUTION TIME-COMPARISON MEASUREMENTS

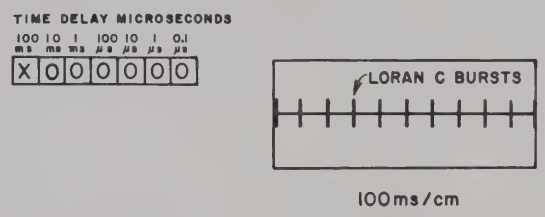
These instructions are intended to show the principles of high-resolution time-comparison measurements and the operation of the μs MARKER. They assume a Loran C repetition rate of 10 c/s which is not available in practice. Loran C chains operate with different repetition rates for identification purposes, (12.5 c/s on the U.S. East Coast) and therefore the Syncronometer and oscilloscope must be setup for the most useful display (stationary Loran C pulse, see paragraph 3.9.4) for the particular Loran C chain used.

The resolution of this technique is 20 ns. It is primarily intended for use with Loran C transmissions but can be used with any signal which allows time comparison to within 1 μs. Both a 1-c/s and a 10-c/s repetition rate are available.

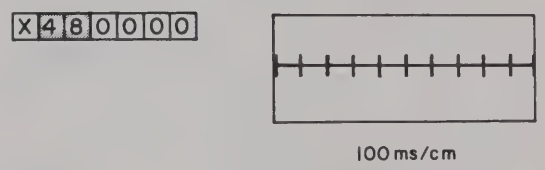
a. Connect the equipment as shown. The μs MARKER of the Syncronometer and the output of the receiver must be added (an oscilloscope with a dual-channel, added algebraically mode is excellent for this purpose).



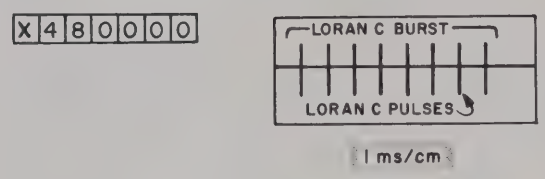
b. Set the 100 ms TIME DELAY control to X (for 10 c/s repetition rate) and set the others to zero. Set the oscilloscope sweep rate to 100 ms/cm.



c. Increase the delay with the 10 ms and 1 ms TIME DELAY controls to move the Loran C pulses left towards the start of the oscilloscope trace.

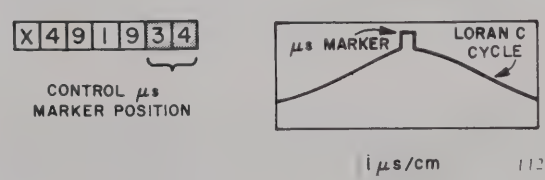


d. Increase the oscilloscope sweep rate to increase the resolution.



e. Increase the delay to move a Loran C pulse to the start of the oscilloscope display. Increase the oscilloscope sweep rate to increase the resolution.

f. Increase the delay to move the third cycle of a Loran C pulse to the center of the display. Increase the Oscilloscope sweep rate to increase the resolution. Position the μs MARKER exactly on top of the cycle with the 1μs and 0.1 μs TIME DELAY controls.



It is not necessary to start the measurement with an oscilloscope sweep rate as slow as 100 ms/cm. The slow sweep rate was chosen for this example to ensure that the pulses appeared on the display. Nor is it necessary to preset all TIME DELAY controls to zero. This was done here to ensure that delay was always added so that it was unnecessary to hunt back and forth for the time tick.

Any pulse may be selected for measurement. It is desirable however, to make the measurement on the third or fourth *cycle* of a pulse because the first few are not as well defined and those after the fourth may be contaminated by sky waves and may contain more noise. The μs MARKER may be positioned on top of the cycle, on the bottom, or on a zero crossing.

• 3.8 SYNCHRONIZATION

The Syncronometer can be synchronized with an external time standard (Synchronizing) or with another Syncronometer (Slaving).

3.8.1 SYNCHRONIZING

Time-of-Arrival Coincidence After a time-comparison measurement has been made, it is possible to synchronize the 1 SEC TICK of the Type 1123-A with the time tick of the *received* standard-time signal (or any other time standard) to within 10 μs.

a. Set the PROGRAM switch to SELF SYNC.

b. Manually subtract 50 μs from the TIME DELAY control setting. This allows for the internal program time in the Type 1123-A.

c. Push the INITIATE button to synchronize the time ticks.

The Type 1123-A 1 SEC TICK is now coincident with the *received* standard time tick to within 10 μs. As a check, a time-comparison measurement can be made; the TIME DELAY controls should read 000 00-.-.

EXAMPLE 1:

749193.4 μs	
− 50.0 μs	
749143.4 μs	

After a time-comparison measurement was made, the TIME DELAY controls read 749193.4 μs. After 50 μs was subtracted, the TIME DELAY controls read 749143.4 μs.

EXAMPLE 2:

1 000034.8 μs	
− 50.0 μs	
999984.8 μs	

After a time-comparison measurement was made, the TIME DELAY controls read 000034.8 μs. After 50 μs was subtracted, the TIME DELAY controls read 999984.8 μs.

Since coincidence is only within 10 μs, the last two TIME DELAY controls (1 μs and 0.1 μs) do not enter into the subtraction or the subsequent check measurement. These dials control only the delay of the μs MARKER with respect to the 8 ms PEDESTAL.

Time-Of-Transmission Coincidence (Correction for propagation delay). After a time-comparison measurement has been made, it is possible to synchronize the 1 SEC TICK of the Type 1123-A with the time tick of the transmitted standard-time signal (or any other time standard) to within 10 μs. The propagation time, however, must be known or must be calculated.

D_M = TIME DELAY control setting after a time-comparison measurement has been made, in μs.

D_T = Propagation time between the standard time transmitter and the receiver, in μs.

D_S = Corrected TIME DELAY control setting for time-of-transmission coincidence, in μs.

a. Calculate $D_M - D_T$.

b. Calculate D_S.

If $D_M - D_T \geq 50\ \mu s$, $D_S = D_M - D_T - 50\ \mu s$.

If $D_M - D_T < 50\ \mu s$, $D_S = 1{,}000{,}000\ \mu s + (D_M - D_T) - 50\mu s$

c. Set the TIME DELAY controls to D_S.

d. Push the INITIATE button to synchronize the time ticks.

The Type 1123-A 1 SEC TICK is now coincident with the ***transmitted*** standard time tick to within 10 μs. As a check, a time-comparison measurement can be made; the TIME DELAY controls should read the propagation time (D_T).

EXAMPLE:

749193.4 μs	
− 2600.0 μs	
746593.4	
− 50.0 μs	
746543.4 μs	

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The standard-time transmitter is located 500 miles away and the received signal is a ground wave; therefore the propagation time (D_T) is about 2.6 ms (2600 μs).

After a time-comparison measurement was made; the TIME DELAY controls read 749193.4 μs.

$D_M - D_T = 749193.4 - 2600.0 = 74659.34$, which is greater than 50 μs; therefore $D_S = D_M - D_T - 50\ \mu s = 746543.4\ \mu s$.

Since coincidence is only within 10 μs, the last two TIME DELAY controls (1 μs and 0.1 μs) do not enter into the subtractions or the subsequent check measurement.

3.8.2 SLAVING

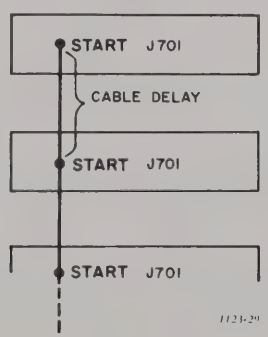
If the clock is stopped, a signal applied to its rear-mounted START connector will start it regardless of the position of its PROGRAM switch. If the clock is running, the signal will have no effect.

General The START connector is an input/output connector. It is wired directly to the Input Circuit and serves as an input connector which is independent of the PROGRAM switch. It is connected to the output of the start pulse generator in the START, SELF SYNC, and START SLAVE positions of the PROGRAM switch and produces an output in these positions whenever the INITIATE button is pushed.

If two or more Syncronometers are cabled together by means of the start connectors and the INITIATE button is pushed on one when it is set for the START, SELF SYNC, or START SLAVE PROGRAM, its resultant START pulse output will start any of the other Syncronometers not already started.

Connections One or more Syncronometers can be slaved (synchronized) to a master to within 10 μs when the rear-mounted START connectors are cabled together. The same 100-kc drive source may be used for all Syncronometers or separate drive sources may be used. The sources need not be coherent (in phase) but must be stable for any lasting synchronization. Any one of the Syncronometers can be selected as the master.

CONNECTIONS



Start Syncronometers simultaneously

Initial conditions: All Syncronometers stopped.

a. Turn the PROGRAM switch of all Syncronometers to STOP and push the INITIATE buttons to set their first five decades to zero (all clocks zeroed).

If required, set the visual registers (refer to paragraph 3.4.1).

b. Turn the PROGRAM switch of all Syncronometers, except one, to OPERATE.

c. Turn the PROGRAM switch of the remaining Syncronometer (master) to START.

d. Push the INITIATE button of the master to start all Syncronometers.

The leading edges of the 1 SEC TICKS of all Syncronometers are now coincident except for differences, up to 10 μs, caused by the 100-kc drive-signal phase relationships and except for the delay in cabling between the START connectors.

Slave on time of arrival

Initial conditions: Master running, slave stopped.

a. Turn the PROGRAM switch of the slave Syncronometer to STOP and push the INITIATE button to set the first five decades to zero (clock zeroed).

If required, set the visual register (refer to paragraph 3.4.1).

b. Turn the slave PROGRAM switch to OPERATE.

c. Turn the master PROGRAM switch to START SLAVE and set the TIME DELAY controls to 000 00.

d. Push the master INITIATE button to start the slave.

The leading edges of the 1 SEC TICKS of the master and slave are now coincident except for differences, up to 10 μs, caused by the 100-kc drive-signal phase relationships and except for the delay in the cabling between the START connectors.

Slave on time of transmission (Correction for cable delay.)

Initial Conditions: master running, slave stopped.

a. Turn the PROGRAM switch of the slave Syncronometer to STOP and push the INITIATE button to set the first five decades to zero (clock zeroed).

If required, set the visual register (refer to page paragraph 3.4.1).

b. Turn the slave PROGRAM switch to OPERATE.

c. Turn the master PROGRAM switch to START SLAVE and set the TIME DELAY controls to 1.000 00 – D_T, where D_T is the cable delay (known or calculated) in μs.

d. Push the master INITIATE button to start the slave.

The leading edges of the 1 SEC TICKS of the master and slave are now coincident except for differences, up to 10 μs, caused by the 100-kc drive-signal phase relationships.

Slave after time of transmission

Initial conditions: master running, slave stopped.

a. Turn the PROGRAM switch of the slave Syncronometer to STOP and push the INITIATE button to set the first five decades to zero (clock zeroed).

If required, set the visual register (refer to page paragraph 3.4.1).

b. Turn the slave PROGRAM switch to OPERATE.

c. Turn the master PROGRAM switch to START SLAVE and set the TIME DELAY controls for the delay desired between the slave and master (if required, take into account the cable delay).

d. Push the master INITIATE button to start the slave.

The leading edge of the slave 1 SEC TICK now follows the leading edge of the master 1 SEC TICK by an amount equal to the master TIME DELAY control setting except for differences, up to 10 μs, caused by the 100-kc drive-signal phase relationships and except for the delay in the cabling between the START connectors, if it was not taken into account.

• 3.9 PRINCIPLES OF TIME MEASUREMENTS

3.9.1 TIME AND FREQUENCY

Time is one of the three fundamental physical dimensions. Since frequency is specified in terms of events per unit time (cycles per second), the production of an accurate frequency is directly related to the establishment of an exact time interval.

3.9.2 DIRECT TIME COMPARISON

Frequency may be established to a high degree of precision by direct comparison of time references derived from the frequency to be measured and from a standard. $\frac{\Delta f}{f} = \frac{\Delta t}{t}$, where

f = nominal frequency of oscillator.

Δf = difference between nominal frequency of oscillator and a standard frequency.

t = interval between two time-comparison measurements.

Δt = difference in time delay between first and second time-comparison measurements.

The time reference compared is usually a one-second interval, derived from the frequency to be calibrated by a precision electronic clock such as the Type 1123 Digital Syncronometer. There are two distinct advantages of this method of comparison over others:

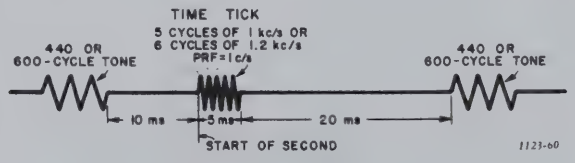
(1) Individual measurements do not have to have great accuracy since the accuracy is increased by taking longer and longer time intervals between measurements.

(2) The measurement results in an accurately set local clock. Local time is known to the extent that the propagation time of the radio signal is known.

3.9.3 WWV-TYPE SIGNAL CHARACTERISTICS

Astronomical time observations are carried out by national observatories throughout the world and their measurements are made available to users by radio time-signal transmissions in their respective countries. Although the broadcast frequencies, type of information, and signal characteristics of each station may differ, nearly all broadcast standard one-second time intervals (time ticks) similar to those broadcast by WWV in the U.S.

Signal



WWV time ticks occur precisely at the start of each second and consist of five cycles of a 1-kc tone (6 cycles of a 1.2-kc tone for WWVH). Twenty-five milliseconds after the end of the time tick, a standard tone 440 or 600 c/s) is broadcast which ends 10 milliseconds before the start of the next time tick.

Other information broadcast at regular intervals includes voice, binary-coded and Morse-coded day-of-year and time-of-day information, and radio propagation notices.

Accuracy

Time ticks, as transmitted, are accurate to within ±2 parts in 10^8 + 1 μs. Received time ticks may be as accurate as those transmitted for several hours during total daylight or total darkness but ordinarily will vary ±2 parts in 10^8 + 500 μs due to ionospheric changes. Severe ionospheric storms can cause variances up to several ms.

Total variances that can be expected are approximately as follows:

worst	(long distances from transmitter, severe ionospheric disturbances)	≈±3 ms
moderate	(medium distances from transmitter, moderate ionospheric disturbances)	≈±500 μs
possible	(short distances from transmitter, excellent signal conditions)	≈±100 μs

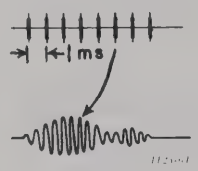
WWV-TYPE HF TRANSMISSIONS

Call Sign	*Site*	*Latitude*	*Longitude*	*Frequency*
WWV	Beltsville, Maryland, USA	38°51'N	76°50'W	2.5, 5, 10, 15, 20, and 25 Mc/s
WWVH	Maui, Hawaii, USA	20°46'N	156°28'W	5, 10, and 15 Mc/s
CHU	Ottawa, Canada	45°17'N	75°45'W	3.33, 7.335, and 14.67 Mc/s
HBN	Neuchatel, Switzerland	47°00'N	6°57'E	5 Mc/s
JJY	Tokyo, Japan	35°42'N	139°31'E	2.5, 5, 10, and 15 Mc/s
MSF	Rugby, U.K.	52°22'N	1°11'W	2.5, 5, and 10 Mc/s
ZVO	Johannesburg, Union of South Africa	26°11'S	28°04'E	10 Mc/s
ZVO	Olyantsfontein, Union of South Africa	25°58'S	28°14'E	5 Mc/s

3.9.4 LORAN C SIGNAL CHARACTERISTIC

Loran C transmitter chains are intended primarily for navigational purposes but their signal characteristics make them valuable as time standards. There are several transmitters in each chain, a master and one or more slaves. Timing of the East Coast chain is controlled by the Naval Observatory.

Signal



The transmissions consist of pulse groups of 100 kc/s, each group contains eight pulses spaced one ms apart (9 pulses for a master). Individual transmitters in a chain are identified by different emission delays and phase coding. Emission delay is the time interval between the receipt of the master stations signal at a slave and the slave's transmission of the corresponding pulse group. Pulse coding is the relative phase of cycles within a pulse.

Individual *chains* are identified by different pulse-group repetition rates (12.5 c/s for the East Coast chain). Although the Loran C and Syncronometer repetition rates differ, a stable oscilloscope display is achieved by virtue of the coincidence rate of the two signals (difference of the two repetition rates). Thus, for a high-resolution time-comparison measurement using a Loran C signal from the East Coast chain, the display will consist of stationary pulses at a 2.5 c/s rate.

Accuracy

Because Loran C transmitters broadcast on a lower frequency than most WWV-type transmitters, their ground waves extend further and their signals are therefore less subject to ionospheric changes. As a result, received Loran C signals at their worst are as accurate as received WWV-type signals at their best.

Total variances that can be expected are approximately as follows:

worst	(over 600 miles from transmitter)	$\approx \pm 100\ \mu s$
moderate	(200 to 600 miles from transmitter)	$\approx \pm 1\ \mu s$
possible	(less than 200 miles from transmitter)	$\approx \pm 0.1\ \mu s$

Resolutions given are possible with simple receiving equipment and techniques. Resolutions of ±20 μs at distances of 1000 miles or greater are possible, however, depending on local noise, receiver characteristics, and operator techniques.

LORAN C EAST-COAST-CHAIN TRANSMISSIONS

Designation	*Site*	*Latitude*	*Longtitude*	*Frequency*	*Rep Rate*
M	Cape Fear, North Carolina, USA	34°03.8'N	77°54.8'W	100 kc/s	12.5 c/s
W	Jupiter Inlet, Florida, USA	27°02.0'N	80°06.9'W	100 kc/s	12.5 c/s
X	Cape Race, Newfoundland	46°46.5'N	53°10.5'W	100 kc/s	12.5 c/s
Y	Nantucket, Massachusetts, USA	41°15.2'N	69°58.7'W	100 kc/s	12.5 c/s

TIME CONVERSION TO SECONDS

TIME	TIME IN SECONDS	TIME	TIME IN SECONDS	TIME	TIME IN SECONDS	TIME	TIME IN SECONDS
1 MIN	= 6.00 x 10	29	1.74	56	3.36	24	8.64
2	1.20 x 10^2	30	1.80	57	3.42	1 DAY	= 8.64 x 10^4
3	1.80	31 MIN	= 1.86 x 10^3	58	3.48	2	1.73 x 10^5
4	2.40	32	1.92	59	3.54	3	2.59
5	3.00	33	1.98	60	3.60	4	3.46
6	3.60	34	2.04	1 HR	= 3.60 x 10^3	5	4.32
7	4.20	35	2.10	2	7.20	6	5.18
8	4.80	36	2.16	3	1.08 x 10^4	7	6.05
9	5.40	37	2.22	4	1.44	1 WK	= 6.05 x 10^5
10	6.00	38	2.28	5	1.80	2	1.21 x 10^6
11 MIN	= 6.60 x 10^2	39	2.34	6	2.16	3	1.82
12	7.20	40	2.40	7	2.52	4	2.42
13	7.80	41 MIN	= 2.46 x 10^3	8	2.88	*1 MO	= 2.42 x 10^6
14	8.40	42	2.52	9	3.24	*2	4.84
15	9.00	43	2.58	10	3.60	*3	7.26
16	9.60	44	2.64	11 HR	= 3.96 x 10^4	*4	9.68
17	1.02 x 10^3	45	2.70	12	4.32	*5	1.21 x 10^7
18	1.08	46	2.76	13	4.68	*6	1.45
19	1.14	47	2.82	14	5.04	*7	1.69
20	1.20	48	2.88	15	5.40	*8	1.94
21 MIN	= 1.26 x 10^3	49	2.94	16	5.76	*9	2.18
22	1.32	50	3.00	17	6.12	*10	2.42
23	1.38	51 MIN	= 3.06 x 10^3	18	6.48	*11	2.66
24	1.44	52	3.12	19	6.84	*12	2.90
25	1.50	53	3.18	20	7.20	*13	3.15
26	1.56	54	3.24	21 HR	= 7.56 x 10^4		
27	1.62	55	3.30	22	7.92	1 YR	= 3.15 x 10^7
28	1.68			23	8.28		

* 28-day (4-week) months.

MEASUREMENT PRECISIONS

MEASUREMENT INTERVAL (ϵ)	* PRECISIONS POSSIBLE, PARTS IN 10^{10} NORMAL-RESOLUTION MEASUREMENT (10μs) ON A WWV-TYPE SIGNAL worst (±3ms)	moderate (±500μs)	possible (±100μs)	HIGH-RESOLUTION MEASUREMENT (0.1μs) ON A LORAN C SIGNAL worst (±100μs)	moderate (±1μs)	possible (±0.1μs)
1 m	502,000	85,000	18,300	16,700	183	**33.3**
5 m	100,000	17,000	3,670	3,330	36.7	**6.66**
15 m	33,400	5,670	1,220	1,110	**12.2**	**2.22**
17 m	29,500	5,000	1,080	980	**10.8**	**1.96**
30 m	16,700	2,830	**611**	556	**6.11**	**1.11**
1 h	8,360	1,420	**306**	**278**	**3.06**	0.56
24 h	**348**	**59.0**	**12.7**	**11.6**	0.127	0.0231
28 h	**301**	**51.0**	**11.0**	**10.0**	0.110	0.0200
48 h	174	29.5	6.36	5.78	0.0636	0.0116
72 h	116	19.7	4.25	3.86	0.0425	0.00772

Bold face numbers indicate range of reasonable measurements. The calculations listed are intended as an estimation of the precisions possible. Actual measurements to precisions of greater than 1 x 10^{-10} are unlikely because the oscillator would probably drift this amount in the time interval required. Continuous logging should allow frequency settings to parts in 10^{10} with Loran C and parts in 10^9 with WWV.

If second TIME DELAY reading is smaller than the first, error is negative (-), oscillator frequency is low, and Syncronometer is losing time (running too slow).

If second TIME DELAY reading is larger than the first, error is positive (+), oscillator frequency is high, and Syncronometer is gaining time (running too fast).

*Precision possible includes affects of measurement resolution and received-signal variances:

$$\text{precision} = \frac{\text{resolution} + \text{signal variance}}{\text{measurement interval}}$$

3.9.5 RESOLUTION AND PRECISION

The time interval between time-comparison measurements necessary for a given precision and the resolution of the measuring system are directly related. The greater the resolution, the shorter the time interval necessary: $\frac{\Delta f}{f} = \frac{\Delta t}{t}$, where:

$\frac{\Delta f}{f}$ = desired precision; parts in 10^{10}.

t = interval between time-comparison measurements.

Δt = resolution of measuring system.

For normal-resolution measurements (10^{-5} resolution), the time interval necessary for a precision of 1 part in 10^{10} =

$$t = \frac{\Delta f}{f}\,\Delta t = 10^{10} \times 10^{-5} = 10^{5} \approx 28 \text{ hours.}$$

For high-resolution measurements (10^{-7} resolution), the time interval necessary for a precision of 1 part in 10^{10} =

$$t = \frac{\Delta f}{f}\,\Delta t = 10^{10} \times 10^{-7} = 10^{3} \approx 17 \text{ minutes.}$$

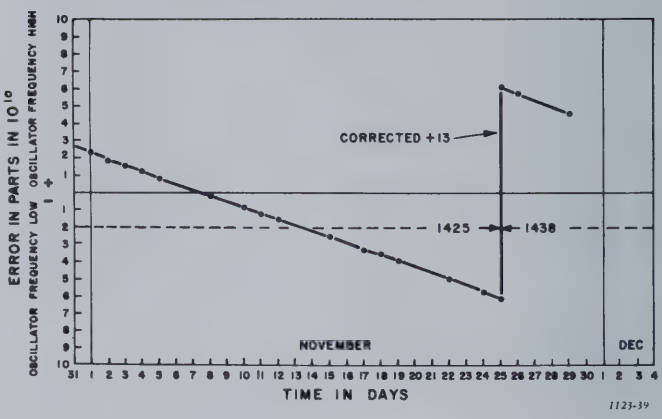
3.9.6 ERROR COMPUTATIONS

PROCEDURE	EXAMPLE
Considerations 1. Measurement precision desired. 2. Measurement resolution available. 3. Measurement speed desired. 4. Standard-time transmissions available. The lower table lists the measurement precisions possible with given standard-time signals, measurement intervals, and measurement resolutions. Note how the effects of signal variances decrease as the measurement intervals increase. Note also that the measurement precision possible with a high-resolution measurement on a Loran C signal is roughly 400 times that of a normal-resolution measurement on a WWV-type signal. For example, with moderate signal variances, a measurement interval of one hour yields a precision of 1420 x 10^{-10} with a WWV-type signal and 3.06 x 10^{-10} with a Loran C signal.	The frequency of the oscillator that drives the Syncronometer is to be measured to a precision of 1 part in 10^{9} (10 x 10^{-10}). The nominal frequency of the oscillator is 5 Mc/s (divided down to 100 kc/s to drive the Syncronometer). A Loran C signal is available and the oscillator provides a 1-Mc drive signal, so the high-resolution time-comparison technique with the Loran C signal is to be used. The transmitter is located 380 miles away; therefore moderate signal variances are expected and the measurement interval must be at least 17 minutes for the desired precision.
Error Determination After the measurement technique has been selected, determine Δt by making the time-comparison measurements as described in paragraph 3.6 or 3.7. From Δt, determine the Syncronometer error by use of the following formulas: Error in parts in $10^{10} = \frac{\Delta t}{t}$ Error is negative (-) if the second TIME DELAY reading is less than the first and positive (+) if the second reading is greater than the first. Uncertainty Limits = error ± precision possible	Time-comparison measurement results: *Time* — *TIME DELAY* 1st 10 h 43 m — X70549.8 μs 2nd 11 h 00 m — X70483.7 μs t = 17 m Δt = 66.1 μs Error = $\frac{66.1 \times 10^{-6}}{9 \times 10^{2}} = 7.34 \times 10^{-10} \approx -734 \times 10^{-10}$ Uncertainty Limits = -734 ± 10.8 ≈ -723 or -745
Frequency Error = error x oscillator frequency Oscillator frequency is low if error is negative (-), and high if error is positive (+). Frequency-Error Limits = uncertainty limits x oscillator frequency	Frequency error = -734 x 10^{-10} x 5 x 10^{6} = -0.367 c/s Frequency Error Limits = -723 x 10^{-10} x 5 x 10^{6} = -0.362 c/s -745 x 10^{-10} x 5 x 10^{6} = -0.373 c/s
Time Error in period for one second clock error = reciprocal of error Syncronometer is losing time if error is negative (-), and gaining time if error is positive (+). Time Error Limits = reciprocal of error limits.	Time Error = $\frac{1}{-734 \times 10^{-10}} \approx -1.36 \times 10^{7}$ Time error Limits = $\frac{1}{-723 \times 10^{-10}} = -1.38 \times 10^{7} \approx$ 5 mo 3 wk $\frac{1}{-745 \times 10^{-10}} = -1.34 \times 10^{7} \approx$ 5 mo 3 wk
Conclusion The oscillator frequency, at the time of measurement, is 0.362 to 0.373 c/s too low, which causes the Syncronometer to lose time at a rate of approximately one second every 5½ months. In addition, oscillator drift will affect the rate at which the Syncronometer gains or loses time.	

3.9.7 PERFORMANCE RECORDS

Performance records are necessary to the user who desires a continuous check on the accuracy of his oscillator. A log is indispensable; a chart is convenient.

In the example, a Loran C transmission was the basis for computing the oscillator error. As a check on the Loran C transmissions, time-comparison measurements were also made on two other standard-time transmissions (WWV and CHU) to ensure Δt was not seriously in error.



LORAN C 100 kc/s Nantucket						WWV 5 Mc/s			CHU 7335 kc/s		
DATE	TIME	t	TIME DELAY	Δt (μs)	ERROR (parts in 10^{10})	TIME	TIME DELAY	Δt (μs)	TIME	TIME DELAY	Δt (μs)
Oct 29	1000	24 h	X27397.5	28.9	+3.35	1015	198370.0	30.0	1030	385630.0	30.0
Nov 1	1000	72 h	X27457.3	59.8	+2.30	1015	198430.0	60.0	1030	385690.0	60.0
2	1000	24 h	X27474.5	17.2	+1.99	1015	198450.0	20.0	1030	385710.0	20.0
3	1000	24 h	X27489.7	15.2	+1.76	1015	198470.0	20.0	1030	385720.0	10.0
4	1000	24 h	X27500.6	10.9	+1.26	1015	198480.0	10.0	1030	385730.0	10.0
5	1000	24 h	X27508.3	7.7	+0.893	1015	198490.0	10.0	1030	no difference	
8	1000	72 h	X27503.6	4.7	-0.181	1015	198480.0	10.0	1030	no difference	
9	1000	no measurement				1015	fading		1030	fading	
10	1000	48 h	X27488.4	15.2	-0.879	1015	198470.0	10.0	1030	missed	
11	1000	24 h	X27477.9	10.5	-1.22	1015	198460.0	10.0	1030	385710.0	20.0
12	1000	24 h	X27464.5	13.4	-1.55	1015	198450.0	10.0	1030	385700.0	10.0
15	1000	72 h	X27497.5	66.8	-2.58	1015	198380.0	70.0	1030	385640.0	60.0
16	1000	receiver inoperative				1015	198350.0	30.0	1030	missed	
17	1000	48 h	X27341.0	56.7	-3.28	1015	198320.0	30.0	1030	385590.0	50.0
18	1000	24 h	X27309.3	31.7	-3.68	1015	198290.0	30.0	1030	385560.0	30.0
19	1000	24 h	X27275.4	33.9	-3.93	1015	198260.0	30.0	1030	385530.0	30.0
22	1000	72 h	X27262.5	129	-4.98	1015	198130.0	130.0	1030	385400.0	130.0
23	1000	no measurement				1015	obscured		1030	obscured	
24	1000	48 h	X27162.8	99.7	-5.76	1015	missed		1030	fading	
25	1000	24 h	X27110.0	52.8	-6.12	1015	197980.0	150.0	1030	385250.0	150.0
25	1030	RESET OSCILLATOR			+13 (from 1425 to 1438)						
25	1100		X27112.2								
25	1200	1 h	X27114.4	2.2	+6.12						
26	1200	24 h	X27163.7	49.3	+5.72	1215	198030.0	50.0	1230	385300.0	50.0
29	1200	72 h	X27282.7	119	+4.59	1215	198150.0	120.0	1230	385420.0	120.0

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SECTION 4

PRINCIPLES OF OPERATION

The logic diagram on page 73 complements the discussion in this section. The operation of the Type 1123-A Digital Syncronometer is explained in terms of its basic operating modes; therefore a complete description of any one circuit may consist of several isolated paragraphs.

		page
4.1	TIMEKEEPING	34
4.2	DIVIDER FEATURES	35
4.3	TIME CYCLE	35
4.4	NORMAL-RESOLUTION TIME-COMPARISON	36
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CROSS REFERENCE TO CIRCUIT

Circuit	*Heading*	*Paragraph*
Power Supply	Power Supply	4.9
Logic Circuit	Program	4.8
Input Circuit	Timekeeping Program	4.1
Inhibit Circuit	External Connectors	4.10
Decade Dividers	Timekeeping	4.1
Scale-of-Six Dividers Decade Indicator Drivers Scale-of-Six Indicator Drivers	Divider Features	4.2
Hours Matrix Hours Reset	Time Cycle	4.3
Gate Circuit	Normal-Resolution Time Comparison	4.4, 4.5
Delay Generator	High-Resolution Time Comparison	4.6, 4.7

● 4.1 TIMEKEEPING

The Syncronometer is essentially a clock (time keeper), which operates as follows:

Input Circuit A 100-kc sine-wave signal from a precision frequency standard is applied to the Input Circuit at J601. A Schmitt multivibrator shapes the 100-kc sinewaves into 100-kc pulses which are fed through G1 to the first divider, D1.

First five dividers the 100-kc pulses from G1 are applied to a series of five decade dividers (D1 through D5). Each divider scales (divides) by 10 so that the output of D5 is one pulse per second.

Last six dividers The one-second pulses from D5 are applied to another series of dividers (four decade dividers, D6, D7, D8, and D9; and two scale-of-six dividers, DS1 and DS2).

The scale-of-six dividers carry and cycle (provide a pulse to the next divider and return to zero) when they reach a count of 6. Thus, when DS1 has counted to 6 (indicating 60 seconds) it cycles to zero and sends a pulse to D7 which registers a count of 1 minute; DS2 behaves similarly, i.e., when it has counted 60 minutes, D8 advances 1 hour.

Indicator Drivers Binary output from each of the last six dividers is applied to the Indicator Drivers, ID1 through ID6, which convert the binary information to decimal information and supply power to drive the indicators.

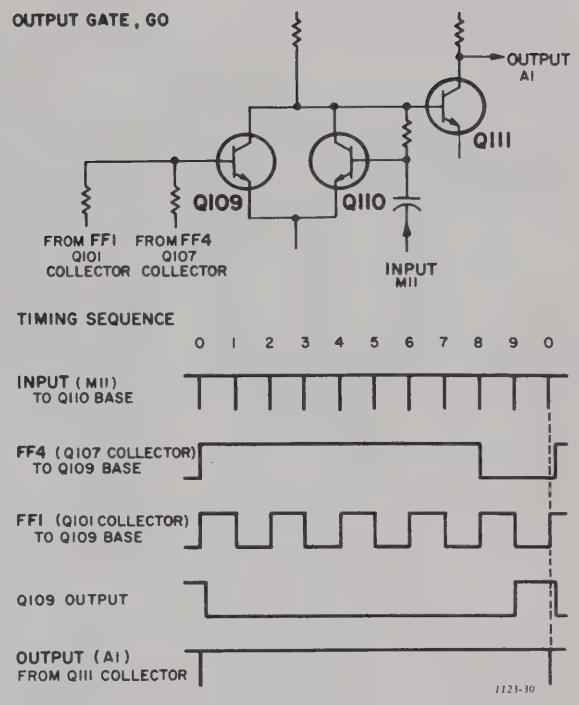
Indicators There are six indicators, each of which is driven by its respective Indicator Driver. The Indicators are incandescent-lamp operated; one lamp for each number.

• 4.2 DIVIDER FEATURES

Anti-time delay An anti-time-delay gate in each divider prevents accumulation of time delay through the divider which would otherwise make 10-μs resolution impossible.

Each divider consists of four binary flip-flops with 1-2-4-2 weighting (1-2-4-8 in the Type 1123-AS1). Since a finite time is required for a flip-flop to change state, there would be a slight delay between the application of the tenth pulse and the generation of a carry pulse without some form of output gate. In the Syncronometer a three-transistor gate limits the total delay between the 100-kc input and the 1-cycle output to less than 1 μs.

Flip-flops 1 and 4 are dc-coupled to the base of Q109 so that this transistor turns off after the application of the ninth input pulse. This then allows the tenth input pulse to pass directly through Q110 and Q111 to the next divider without waiting for the slower 9-to-0 transition of the four flip-flops.

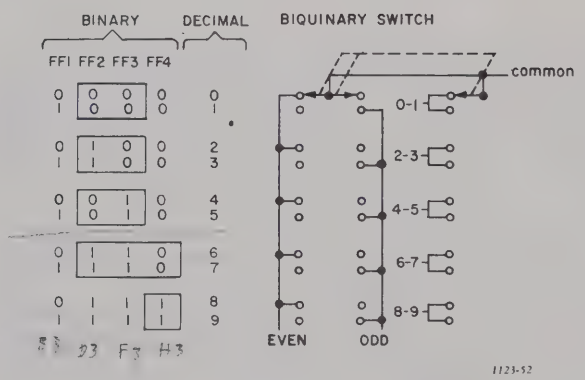


Digital recognition (binary-to-decimal conversion). Each of the eleven dividers in the instrument provides binary coded output information, which must be converted to decimal information before it can be used.

Recognition is accomplished by a biquinary resistor matrix (decimal matrix). The decimal matrix shown, depicts the binary states of the four flip-flops for the digits 0 through 9.

The blocks indicate five unique combinations of states that occur in each case for two adjacent digits (one even and one odd). By using information from the state of FF1, it is possible to recognize either the even or the odd digit of the five decimal pairs, hence the term biquinary.

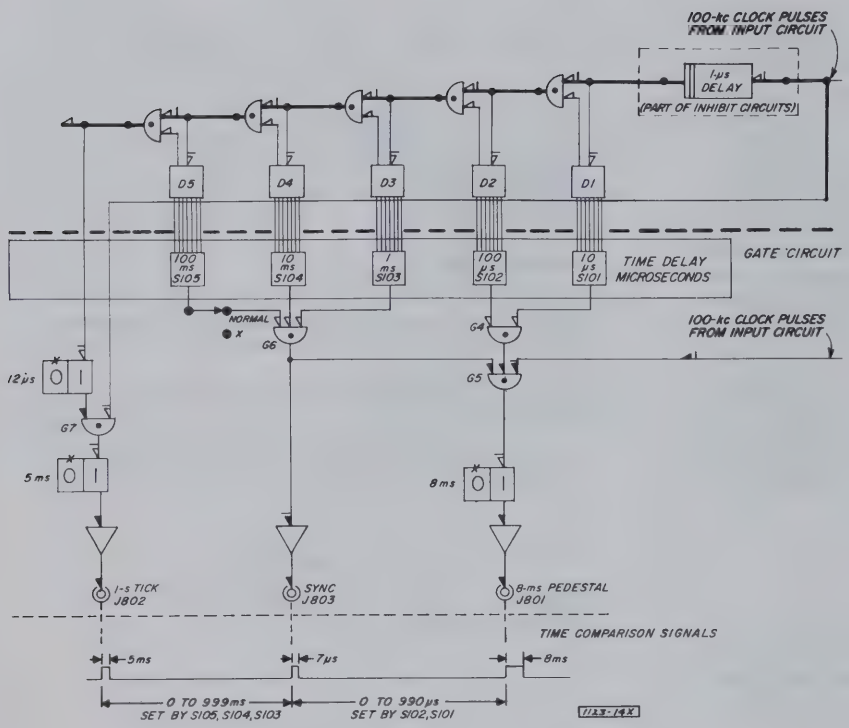
In the last six dividers, the decimal information is applied to the lamp driving circuits in the Indicator Drivers for the visual register. The matrix outputs for the first five dividers, however, are brought to biquinary switches which allow selection of any one of the 10 states by means of thumbwheel switches (TIME DELAY) on the front panel of the instrument.

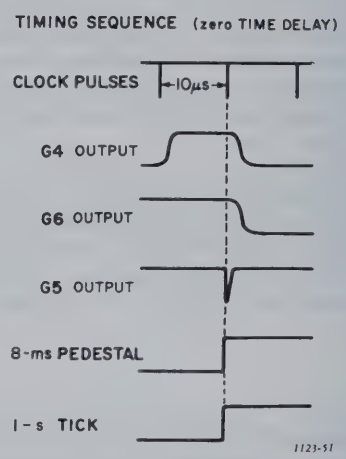


• 4.3 TIME CYCLE

In addition to providing inputs to the HOUR and 10 HOUR indicators, D8 and D9 also provide inputs to the Time Cycle Circuit. This circuit consists of the TIME CYCLE biquinary switches(S401 and S402), the Hours Matrix, and the Hours Reset. It allows the clock (visual register) to cycle to zero after any desired number of hours have elapsed; 1 to 99 as set by S401 and S402.

• 4.4 NORMAL-RESOLUTION TIME-COMPARISON





Gate Circuit The gate circuit provides the means to compare Syncronometer time with standard time to within 10 μs. It operates from inputs supplied by the input circuit and the first five dividers and produces a fixed reference pulse (1 SEC TICK) and two moveable pulses (SYNC and 8 ms PEDESTAL) which are accurately delayed with respect to the reference pulse.

1 SEC TICK the output of D5 triggers a 12-μs monostable multivibrator whose output is applied to G7. The 12-μs output gates the 100-kc clock pulses through G7 which trigger a 5-ms monostable multivibrator whose output is applied to an amplifier. The output of the amplifier is connected to the 1 SEC TICK output connector, J802, on the rear panel.

SYNC The outputs of D3, D4, and D5 are applied through biquinary switches and G6 to an amplifier. The output of the amplifier is a 7-μs pulse which also occurs once each second but which is delayed from the 1 SEC TICK by 0 to 999 ms, depending on the settings of S103, S104, and S105. It is available at the SYNC output connector, J803, on the rear panel.

8 ms PEDESTAL The outputs of D1 and D2 are applied through biquinary switches and two gates (G4 and G5) to a monostable multivibrator which produces an 8-ms pulse. This pulse occurs at the same rate as the SYNC pulse but is delayed from it by 0 to 990 μs, depending on the settings of S101 and S102. It is fed to an amplifier which is connected to the SYNC output connector, J801, on the rear panel.

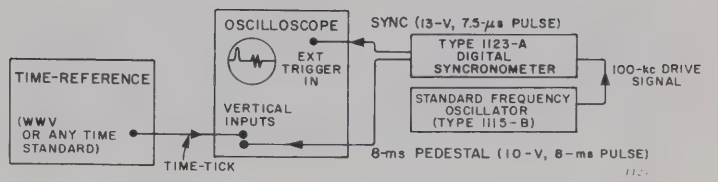
Gate Circuit logic The outputs of the first five dividers are applied to five biquinary switches whose outputs are combined by means of three gates, G4, G5, and G6. The outputs of the first two switches (S101 and S102 with 10 and 100-μs increments, respectively) are combined in "and" gate G4. The next three switch outputs (S103, S104, and S105 with 1, 10, and 100-ms increments, respectively) are combined in "and" gate G6, whose output also generates the SYNC pulse.

The outputs of G4 and G6 are then applied to another "and" gate, G5, together with the 100-kc clock pulses from the input circuit. Since there is a finite delay in the recognition process, the next clock pulse, after recognition, is gated by G5. G5 triggers an 8-ms monostable multivibrator which delivers a 10-V positive signal to the 8 ms PEDESTAL output connector.

The 8 ms PEDESTAL appears at a 1-cycle rate but is delayed with respect to the 1 SEC TICK. With 000 000.0 TIME DELAY, the beginning of the 8 ms PEDESTAL and the 1 SEC TICK are time-coincident. This is accomplished by "and" gate, G7, which triggers the 1 SEC TICK on the same clock pulse that triggered the 8 ms PEDESTAL.

● 4.5 NORMAL-RESOLUTION MEASUREMENT DESCRIPTION

Setup A scope, two Syncronometer outputs, and a standard-time signal are required for normal-resolution time-comparison measurements.



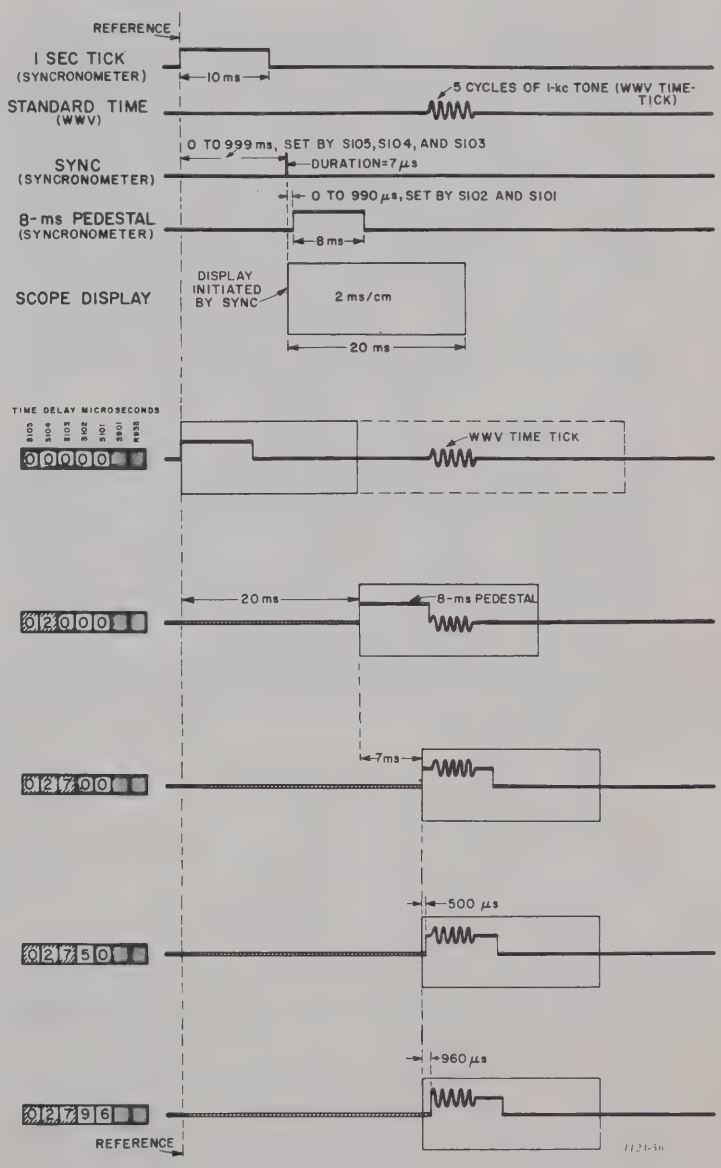
Signal Explanation

a. The leading edge of the SYNC pulse triggers the scope and, with a sweep rate of 2 ms/cm, the display window is 20 ms wide.

b. The repetition rate of all signals is 1 c/s.

c. The standard-time tick and the 1 SEC TICK are stationary.

d. The SYNC and 8 ms PEDESTAL can be delayed with respect to the leading edge of the 1 SEC TICK.



No delay has been inserted between the 1 SEC TICK and the SYNC pulses, therefore the start of the display is coincident with the leading edge of the 1 SEC TICK. The time tick from WWV is not visible, but if a sweep rate of 5 ms/cm were used (dashed lines), it would be visible.

It is desired to view the time tick from WWV; therefore 20 ms of delay are added by advancing the 10 ms TIME DELAY control (S104) from 0 to 2.

The time tick is placed on top of the 8 ms PEDESTAL by advancing the 1 ms TIME DELAY control (S103) from 0 to 7.

The 8 ms PEDESTAL is moved from the start of the display towards the time tick by advancing the 100 μs TIME DELAY control (S102) from 0 to 5. Note that the 100 μs and 10 μs TIME DELAY controls delay the 8 ms PEDESTAL from the SYNC pulse.

To position the first cycle of the time tick so that is coincident with the start of the 8 ms PEDESTAL, more delay is added by means of the 10 μs TIME DELAY control (S101). The TIME DELAY controls read 027960 μs which is the time difference between the leading edge of the 1 SEC TICK and the start of the first cycle of the WWV time tick.

● 4.6 HIGH-RESOLUTION TIME-COMPARISON

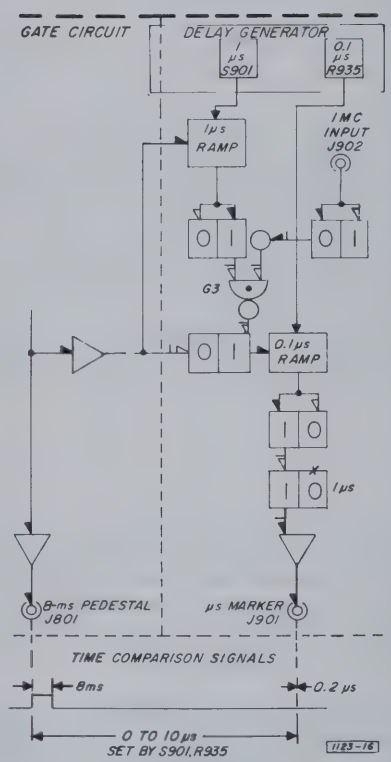
Delay Generator Circuit The delay generator circuit provides the means to compare Syncronometer time with standard time to within 20 ns. It operates from inputs supplied by the gate circuit and an external 1-Mc signal (coherent with the 100-kc drive signal) and provides a variable pulse (μs MARKER) that is accurately delayed with respect to the 8 ms PEDESTAL.

1 μs TIME DELAY The leading edge of the 8 ms PEDESTAL from the gate circuit triggers the 1-μs ramp generator in the delay generator circuit. When the negative-going ramp reaches a preset voltage, it triggers the 100-μs Schmitt circuit. The time delay between the leading edge of the 8 ms PEDESTAL and the Schmitt transition depends on the slope of the ramp. The slope is set by the 1 μs TIME DELAY switch, S901, and is variable in 1μs increments, from 1 to 10 μs (total ramp duration).

The delay is set to the nearest exact multiple of 1 μs by combination, in G3, with the 1-Mc input. The output of G3 triggers a flip-flop which initiates a second ramp generator, the 0.1-μs ramp.

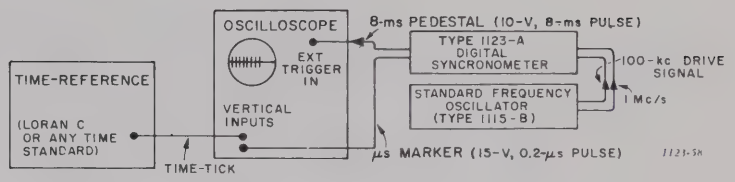
0.1 μs TIME DELAY When the negative-going ramp from the 0.1-μs ramp generator reaches a preset voltage, as before, it triggers the 0.2-μs Schmitt circuit. The time delay between the 10-μs Schmitt transition and the 0.2-μs Schmitt transition depends on the slope of the 0.1-μs ramp. The slope of the ramp is set by the 0.1-μs TIME DELAY dial, R935, and is continuously variable from 0.1 to 1 μs (total ramp duration).

The output of the 0.2-μs Schmitt circuit is shaped, amplified, and applied to the μs MARKER output connector, J901.



• 4.7 HIGH-RESOLUTION MEASUREMENT DESCRIPTION

Setup A scope, two Syncronometer outputs, and a standard-time signal are required for high-resolution time-comparison measurements.



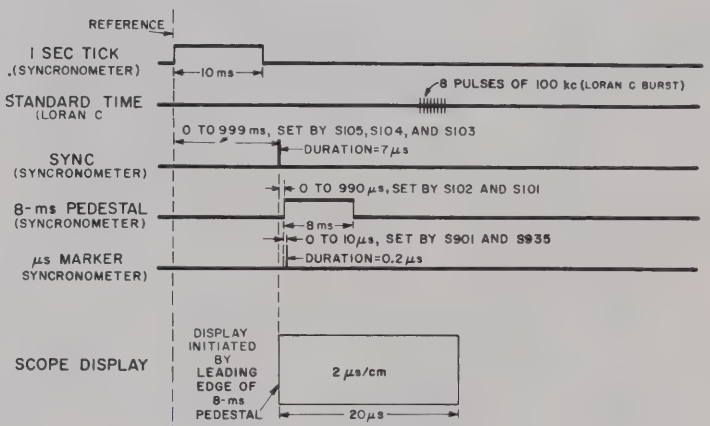
Signal Explanation

a. The leading edge of the 8ms PEDESTAL triggers the scope and, with a sweep rate of 2 μs/cm, the display window in 20 μs wide.

b. The repetition rate of the 1SEC TICK is 1 c/s, and of all other signals it is 10 c/s.

c. The standard-time tick and the 1 SEC TICK are stationary.

d. The SYNC, 8ms PEDESTAL, and μs MARKER are movable, and can be delayed with respect to the leading edge of the 1 SEC TICK.

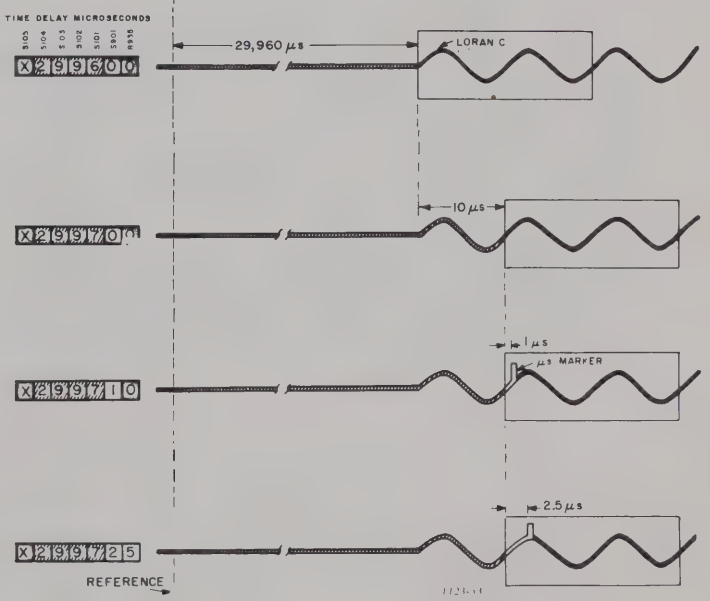

REFERENCE
1 SEC TICK (SYNCRONOMETER)
10 ms
STANDARD TIME (LORAN C
8 PULSES OF 100 kc (LORAN C BURST)
0 TO 999 ms, SET BY S105, S104, AND S103
SYNC (SYNCRONOMETER)
DURATION=7 μs
0 TO 990 μs, SET BY S102 AND S101
8-ms PEDESTAL (SYNCRONOMETER)
8 ms
0 TO 10 μs, SET BY S901 AND S935
μs MARKER SYNCRONOMETER)
DURATION=0.2 μs
SCOPE DISPLAY
DISPLAY INITIATED BY LEADING EDGE OF 8-ms PEDESTAL
2 μs/cm
20 μs

The 100 ms TIME DELAY control has been set to one of its two X positions to establish a 10-c/s repetition rate for the time-comparison signals. The 10 ms through 10 μs TIME DELAY controls have been set to allow the first Loran C pulse to appear on the display.

It is desired to view the second cycle of the Loran C pulse; therefore 10 μs of delay are added by advancing the 10 μs TIME DELAY control (S101) from 6 to 7.

The μs MARKER is brought towards the second cycle by advancing the 1 μs TIME DELAY control (S901) from 0 to 1.

To position the μs MARKER on top of the second cycle, more delay is added by means of the 1 μs and 0.1 μs TIME DELAY controls (S901 and R935).



• 4.8 PROGRAM

The operating mode of the Syncronometer is controlled by the PROGRAM switch, S701. There are six modes, described in the following paragraphs, in the timing diagram of page 47 and in the logic diagram on page

4.8.1 OPERATE

Allows timekeeping operation. In the OPERATE PROGRAM the INITIATE button has no effect and all logic circuit functions are locked out. Although the input circuit is essential to all operations of the Syncronometer (not just the OPERATE PROGRAM), its fail-safe loop is described here because it is closely associated with most of the PROGRAM modes.

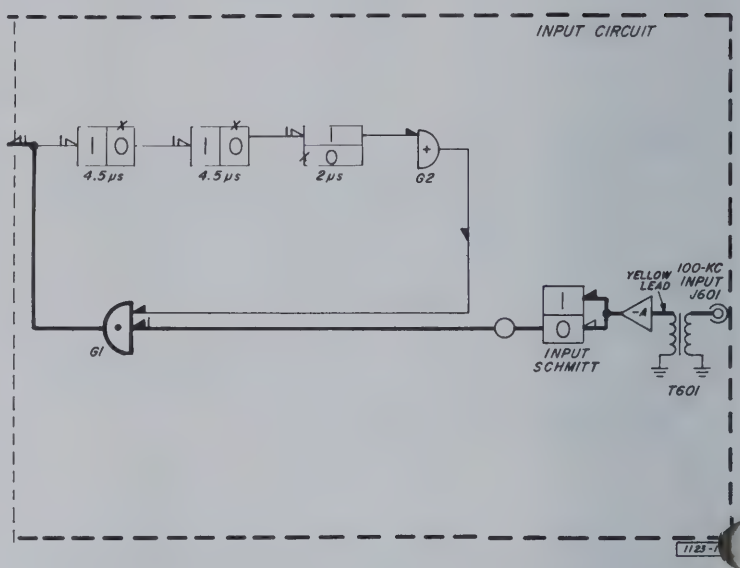
The fail-safe provision in the input circuit stops the clock in the event of an input failure.

The 100-kc input signal is applied at J601, amplified by Q601, and shaped into 100-kc pulses by the input Schmitt circuit, Q602 and Q603. The 100-kc pulses are applied to the "and" gate, G1, which is a part of the fail-safe circuitry. This gate requires two simultaneous inputs before it produces an output. Assume, for the moment, that the second input is present; then G1 produces an output pulse for each 100-kc input pulse it receives from the input Schmitt. These are fed to the first divider, D1, and provide the necessary clock pulses for normal time-keeping operation.

The second input to G1 is derived from the ***output*** of G1 in a type of closed-loop locking circuit for, in addition to supplying pulses to D1, G1 also supplies pulses to a 9-μs delay circuit (two 4.5-μs monostable multis). This circuit produces a pulse 9 μs after it receives a pulse from G1. The leading edge of this delayed pulse triggers a monostable multivibrator which produces a 2-μs output pulse.

The 2-μs pulse is applied to the "or" gate, G2, which produces an output pulse for each input pulse it receives. The output of G2 is the second input to G1.

Note that if the 100-kc input signal fails, the output from G1 stops and, therefore, so does the output from G2. If the 100-kc input signal is restored, the input Schmitt again applies pulses to G1 but G1 produces no output because its second input (from G2) is missing. Thus, once open, the fail-safe loop stays open and only a signal from the logic circuit will close it (START PROGRAM, described next).



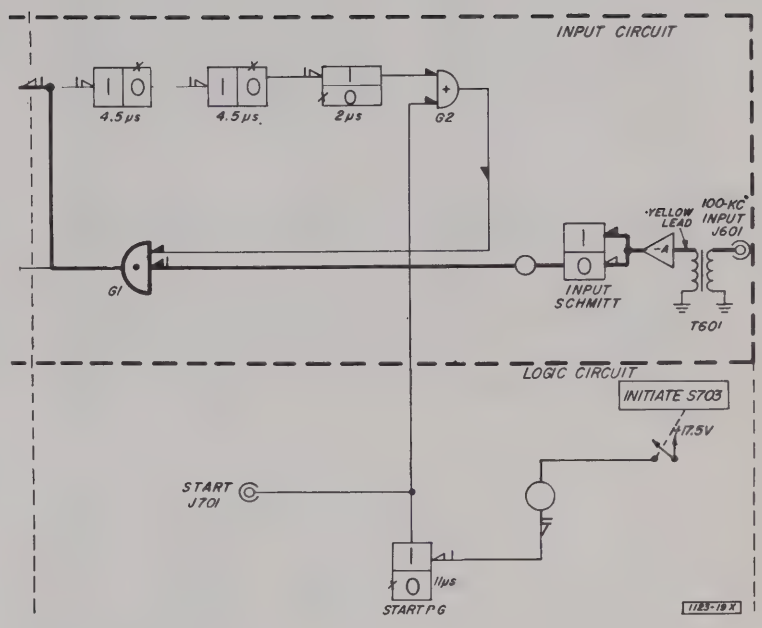
4.8.2 START

Starts timekeeping operation. To close the fail-safe loop and start the timekeeping action, the PROGRAM switch must be set to START and the INITIATE button must be pushed.

When the INITIATE button is pushed, the resulting pulse is amplified by the initiate pulse amplifier and applied through the program switch to the input of the start pulse generator. The output of the start pulse generator is an 11-μs pulse which is connected to the "or" gate, G2, in the input circuit fail-safe loop. This pulse proceeds through G2 to G1 and allows the 100-kc pulses to pass through G1. The 100-kc pulses are fed to D1 to be counted and are fed to the 9-μs delay circuits to close the fail-safe loop and sustain the timekeeping operation.

Note that the 11-μs start pulse from the start pulse generator occurs whenever the INITIATE button is pushed and its time relationship to the other signals is entirely random (indicated by a double-headed arrow on its leading edge in the timing diagram). It is sufficiently long, however, that no matter when it occurs it will be concurrent with at least one 100-kc pulse from the input Schmitt and will thus close the fail-safe loop.

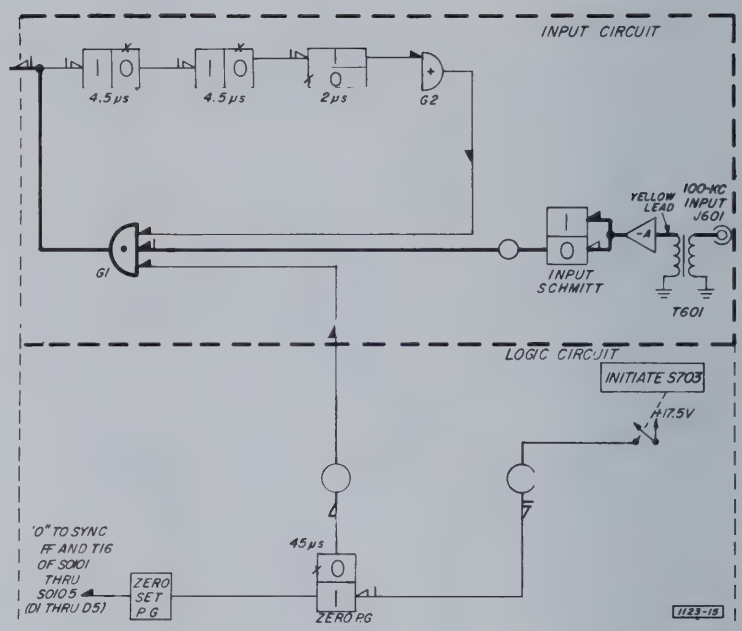
The START pulse is also applied to the START connector, J701, on the rear panel. J701 is an input/output connector, i.e., a START pulse can be obtained *from* it or applied *to* it. The characteristics of the output pulse available and input pulse required are the same.



4.8.3 STOP

Stops timekeeping operation The output of the initiate pulse amplifier is now connected through the PROGRAM switch to the input of the zero pulse generator. When the INITIATE button is pushed, it triggers the zero pulse generator. The output of the zero pulse generator is a 45-μs pulse connector to G2. This pulse disables G2 and thus opens the fail-safe loop and stops the clock.

The output of the zero pulse generator is also connected to the zero set pulse generator. The output of the zero set pulse generator is connected to the zero-set buss of the first five dividers (T16 of SO101 through SO105). When the INITIATE button is pushed, the first five dividers cycle to zero. The last six dividers are not affected and the visual register retains whatever count it had accumulated before the clock was stopped.



4.8.4 SET

Sets digits or time. Three modes of operation are possible when the PROGRAM switch is in the SET position:

1. Set-digits mode (VISUAL REGISTER switch set to any position except hold or OPERATE).

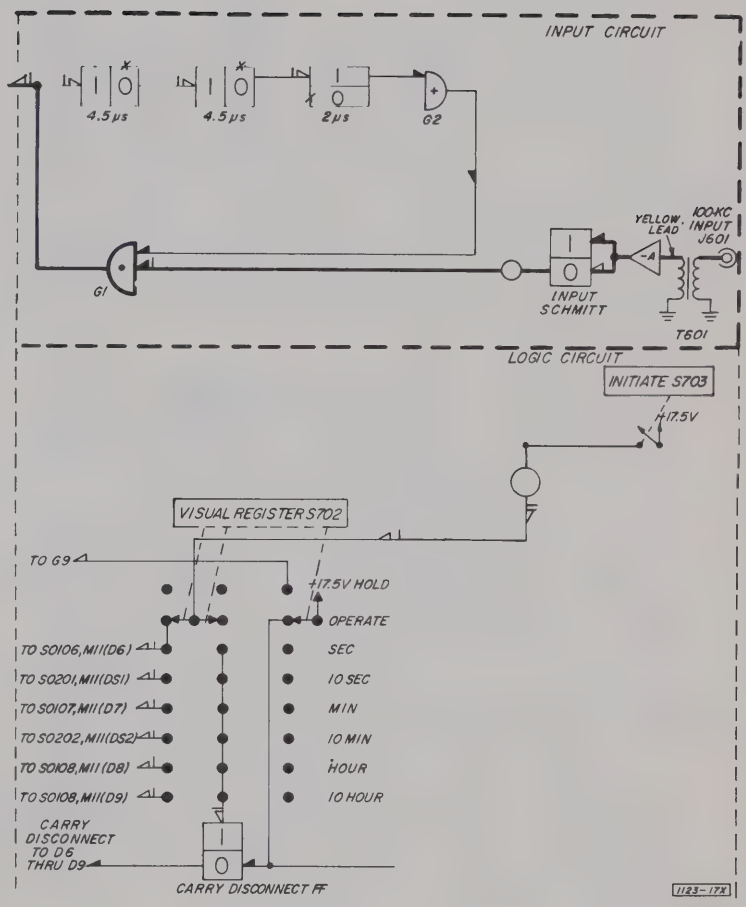
2. Advance-time mode (VISUAL REGISTER switch set to OPERATE).

3. Hold-time mode (VISUAL REGISTER switch set to hold).

In the set-digits mode (VISUAL REGISTER switch set to any one of the bottom six positions), the output of the initiate pulse amplifier is connected through the PROGRAM switch to the VISUAL REGISTER switch, S702. Each time the INITIATE button is pushed, an initiate pulse is sent to the input of whichever of the last six dividers has been selected by the VISUAL REGISTER switch. Each initiate pulse advances the count on the selected divider by one. An initiate pulse is also sent through the PROGRAM switch to the input of the carry disconnect flip-flop. The disconnect pulse disables the gate, G0, between each of the last six dividers, and prevents one divider from carrying its count to the next.

In the advance-time mode (VISUAL REGISTER switch set to OPERATE), the output of the initiate pulse generator is connected only to the input of D5. The seconds indicator, therefore, is the only indicator to advance its count when the INITIATE button is pushed. However, in the advance-time mode, the carry disconnect flip-flop is disconnected and D5 through D9 are allowed to carry. Thus, each time the INITIATE button is pushed, the Syncronometer gains one second.

In the hold-time mode (VISUAL REGISTER switch set to hold, +17.5 V is applied to G9, the gate between the first five dividers and the last six. This voltage disables the gate and prevents the last six dividers from counting. In this mode, the PROGRAM switch disconnects the initiate pulse amplfier from the circuit and, therefore, the INITIATE button has no effect.



4.8.5 SELF SYNC

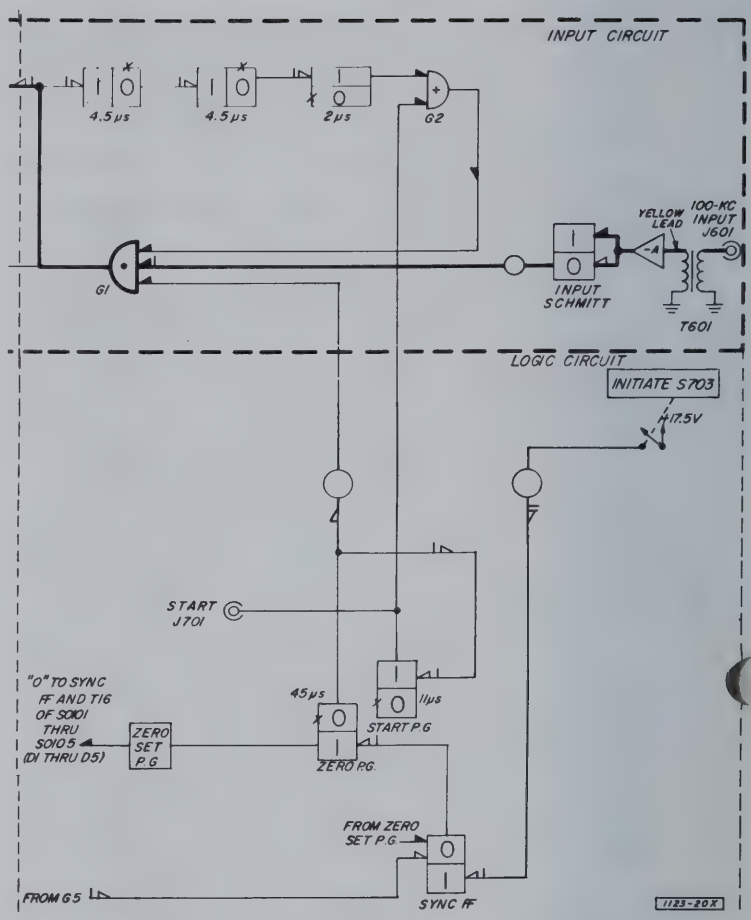
Synchronizes to an external time reference. The output of the initiate pulse amplifier is connected through the PROGRAM switch to the input of the sync pulse generator. This generator is a sequential gate (it requires two sequential inputs before it produces an output). The first input is the initiate pulse and the second is the 8 ms PEDESTAL (from the gate circuit, described earlier).

The TIME DELAY switches in the gate circuit are first set so that the leading edge of the 8 ms PEDESTAL is coincident with the leading edge of the time-reference tick from WWV. They are then set for exactly 50 μs less delay.

When the INITIATE button is pushed, the initiate pulse sets the sync pulse generator to the "1" (positive) state. Some time later, determined by the TIME DELAY switch settings, the 8 ms PEDESTAL occurs. The leading edge of the 8 ms PEDESTAL reverts the sync pulse generator back to the "0" state.

This negative-going transition constitutes the output of the sync pulse generator and it is applied through the PROGRAM switch to the input of the zero pulse generator. The zero pulse generator disables G2, thus opening the fail-safe loop and stopping the clock. Also, via the zero set pulse generator and connections to the zero-set buss of the first five dividers, D1 through D5 cycle to zero. This is the same action that occurs in the STOP PROGRAM.

In the SELF SYNC PROGRAM, however, the output of the zero pulse generator is also connected to the input of the start pulse generator. The trailing edge of the zero pulse triggers the start pulse generator which, starts the clock; coincident with the leading edge of the external time-reference tick.

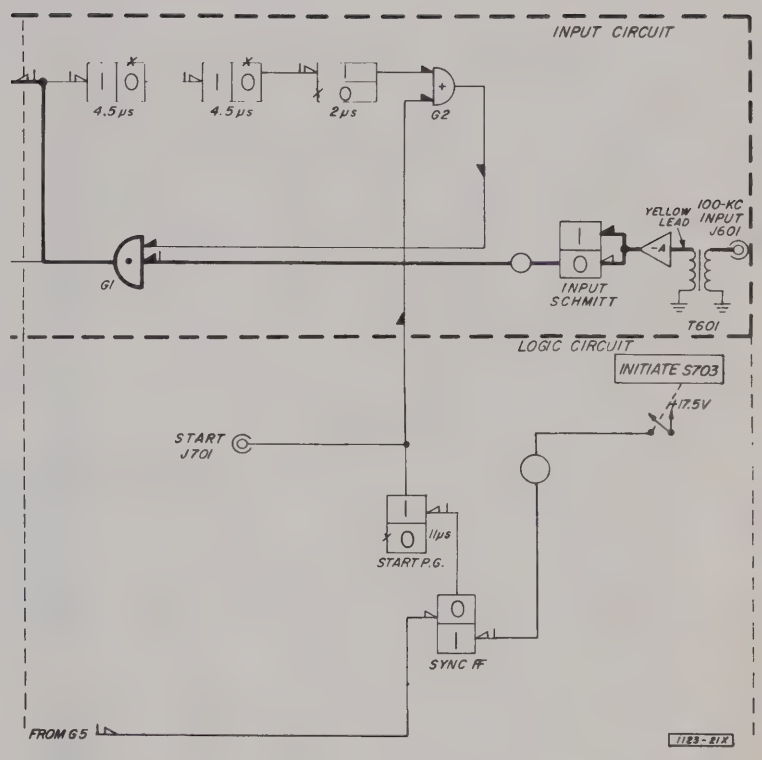


4.8.6 START SLAVE

Synchronizes another Syncronometer. This mode is similar to the SELF SYNC mode except that the sync pulse generator triggers the start pulse generator directly and does *not* trigger the zero pulse generator.

The TIME DELAY switches are set for the desired delay between the master Syncronometer and the slave Syncronometer. If no delay is desired, the TIME DELAY is set to 000 000.0.

When the INITIATE button is pushed, the sync pulse generator changes to the "1" state. The 8 ms PEDESTAL reverts the sync pulse generator to the "0" state which triggers the start pulse generator. The start pulse does not affect the master Syncronometer (the 11-μs pulse it sends to G2 merely reinforces the fail-safe loop). However, when the START output connector, J701, of the master Syncronometer is connected to the START input connector J701, of the slave Syncronometer (J701 functions as both an output and an input connector), the start pulse is applied to G5 of the slave and closes the slaves' fail-safe loop, thus starting the slave clock.

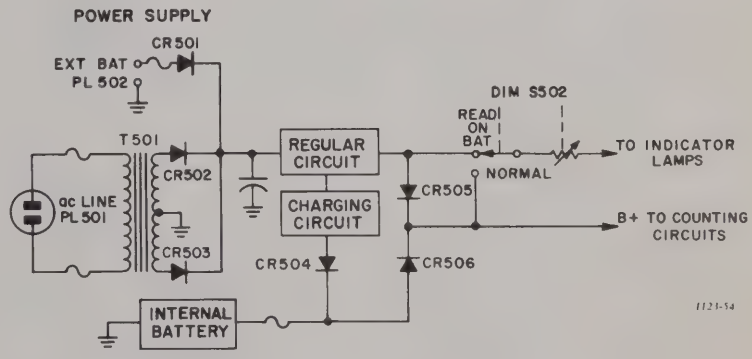


• 4.9 POWER SUPPLY

The power supply is a conventional transistor series-regulator circuit. A built-in explosion-proof, 16-V, nickel-cadmium battery of 4.5 ampere-hour capacity is connected through a rectifier, CR506, to the counting circuits at all times. A temperature-compensated charging circuit supplies a trickle current to the battery so that it stays fully charged.

Supply voltages are set so that the battery normally supplies no current to the counting circuits (CR506 is back-biased). If the ac line voltage fails or drops so that the regulator voltage goes below 17 volts, CR506 becomes forward-biased, and the battery supplies current to the counting circuits. The indicator lamps are disconnected from the battery by CR505 to eliminate their heavy current drain, but a front-panel spring return switch (READ ON BATTERY position of the DIM switch, S502) allows momentary operation of the lamps.

An external 24- to 32-volt battery, connected to the comparator through a rear-panel connector, PL502, can be used to supply the regulator directly in the event of prolonged line-voltage failure.

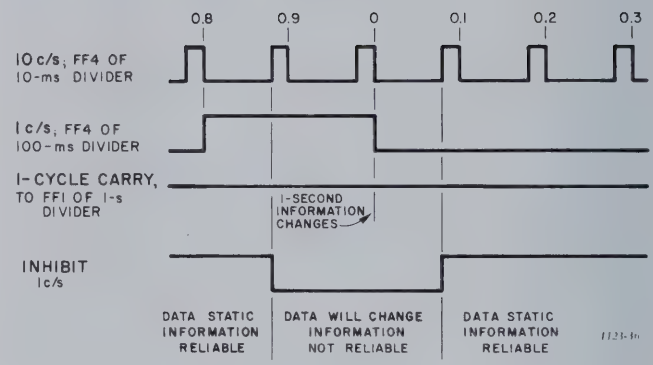


• 4.10 EXTERNAL CONNECTIONS

Nine auxiliary outputs are available to drive external equipment:

Inhibit output An inhibit signal is available from the INHIBIT J651 output connector and pin B13 of the DIGITAL OUTPUT SO501 connector on the rear panel. The INHIBIT signal indicates that the time-of-day information is changing in the instrument and should not be used. The INHIBIT repetition rate can be set in decade steps from 0.1 c/s to 10 kc/s by two internal jumpers on the inhibit board. The rate chosen depends on the time resolution desired and the characteristics of the external equipment.

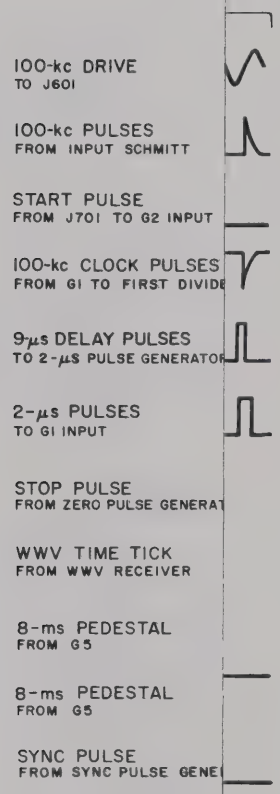
The INHIBIT signal is timed to bracket the divider carry pulse at the particular repetition rate chosen. In the timing diagram, the INHIBIT rate is 1 c/s. It brackets the 10-cycle carry pulse to the 1-cycle (1 second) divider, and prevents the external printer from accepting data during the transition period.



Standard timing pulses Clock pulses (100 kc/s) from the input circuit and the first six dividers (10 kc/s to 0.1 c/s) are buffered and fed to J602 and J101 through J106 on the rear panel.

Type 1123-A time-of-day output lines The outputs of all 11 dividers are connected to the DIGITAL OUTPUT connector, SO501, on the rear panel and provide time-of-day information to within 10 μs to drive an external printer, digital-to-analog converter, or other data processing equipment. This information appears in the form of parallel 1-2-4-2 binary-coded outputs.

Type 1123-AS1 time-of-day output lines The outputs of all 11 dividers are connected through buffer amplifiers to the DIGITAL OUTPUT connector, SO501, on the rear panel and provide time-of-day information to within 10 μs to drive an external printer, digital-to-analog converter, or other data-processing equipment. This information appears in the form of parallel 1-2-4-8 binary-coded outputs (1-2-4-2 coding is also possible).

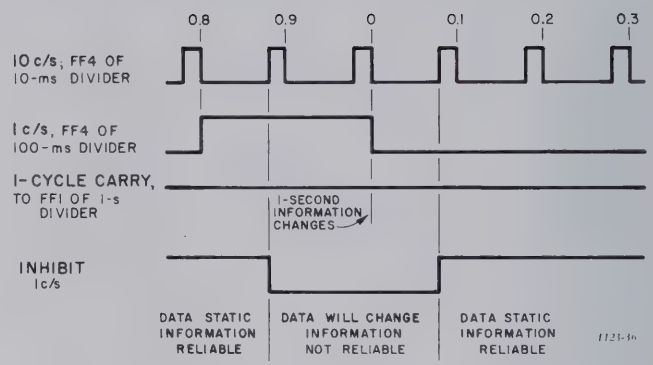

100-kc DRIVE
TO J601
100-kc PULSES
FROM INPUT SCHMITT
START PULSE
FROM J701 TO G2 INPUT
100-kc CLOCK PULSES
FROM G1 TO FIRST DIVIDE
9-μs DELAY PULSES
TO 2-μs PULSE GENERATOR
2-μs PULSES
TO G1 INPUT
STOP PULSE
FROM ZERO PULSE GENERAT
WWV TIME TICK
FROM WWV RECEIVER
8-ms PEDESTAL
FROM G5
8-ms PEDESTAL
FROM G5
SYNC PULSE
FROM SYNC PULSE GENE

• 4.10 EXTERNAL CONNECTIONS

Nine auxiliary outputs are available to drive external equipment:

Inhibit output An inhibit signal is available from the INHIBIT J651 output connector and pin B13 of the DIGITAL OUTPUT SO501 connector on the rear panel. The INHIBIT signal indicates that the time-of-day information is changing in the instrument and should not be used. The INHIBIT repetition rate can be set in decade steps from 0.1 c/s to 10 kc/s by two internal jumpers on the inhibit board. The rate chosen depends on the time resolution desired and the characteristics of the external equipment.

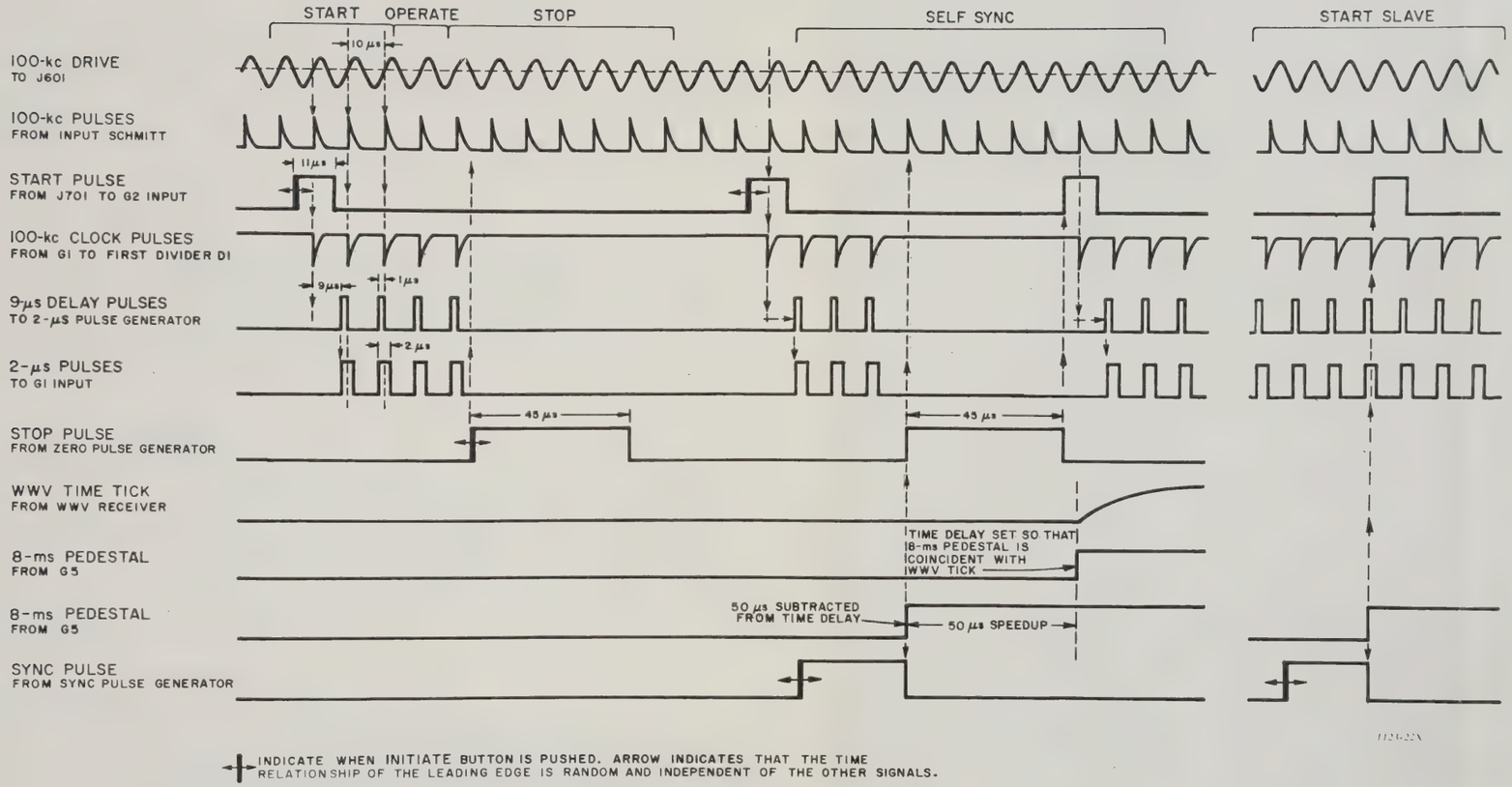
The INHIBIT signal is timed to bracket the divider carry pulse at the particular repetition rate chosen. In the timing diagram, the INHIBIT rate is 1 c/s. It brackets the 10-cycle carry pulse to the 1-cycle (1 second) divider, and prevents the external printer from accepting data during the transition period.



Standard timing pulses Clock pulses (100 kc/s) from the input circuit and the first six dividers (10 kc/s to 0.1 c/s) are buffered and fed to J602 and J101 through J106 on the rear panel.

Type 1123-A time-of-day output lines The outputs of all 11 dividers are connected to the DIGITAL OUTPUT connector, SO501, on the rear panel and provide time-of-day information to within 10 μs to drive an external printer, digital-to-analog converter, or other data processing equipment. This information appears in the form of parallel 1-2-4-2 binary-coded outputs.

Type 1123-AS1 time-of-day output lines The outputs of all 11 dividers are connected through buffer amplifiers to the DIGITAL OUTPUT connector, SO501, on the rear panel and provide time-of-day information to within 10 μs to drive an external printer, digital-to-analog converter, or other data-processing equipment. This information appears in the form of parallel 1-2-4-8 binary-coded outputs (1-2-4-2 coding is also possible).



INDICATE WHEN INITIATE BUTTON IS PUSHED. ARROW INDICATES THAT THE TIME RELATIONSHIP OF THE LEADING EDGE IS RANDOM AND INDEPENDENT OF THE OTHER SIGNALS.

SECTION 5

SERVICE AND MAINTENANCE

page

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5.2 SERVICE 49
5.3 REPLACING INDICATOR LAMPS 49
5.4 TROUBLE-SHOOTING GUIDE 50
5.5 CALIBRATION PROCEDURE 52

• 5.1 WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship, and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory Sales Engineering Office, or authorized repair agency personnel, will be repaired, or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

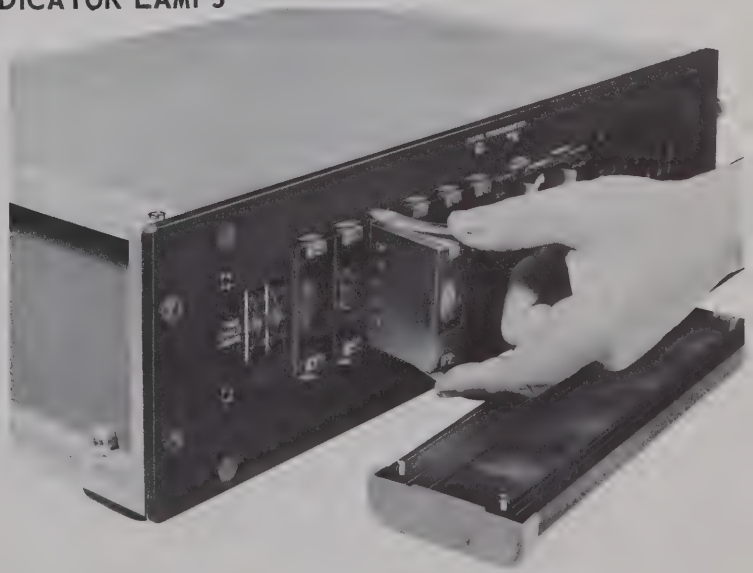
• 5.2 SERVICE

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department (see rear cover), giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please write to our Service Department or nearest Sales Engineering Office, requestion a Returned Material Tag. Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

• 5.3 REPLACING INDICATOR LAMPS

Pull off the protective bezel. Grasp the indicator retaining springs between the thumb and index finger, compress the springs, and pull the indicator out. Replace the defective lamp and reinstall the indicator with the numbered circles to the left as shown in the adjacent figure.



● 5.4 TROUBLE-SHOOTING GUIDE

This guide is designed to isolate the trouble to an etched board. All checks can be made with the cabinet on using a dual-trace, dc-to-15-Mc oscilloscope.

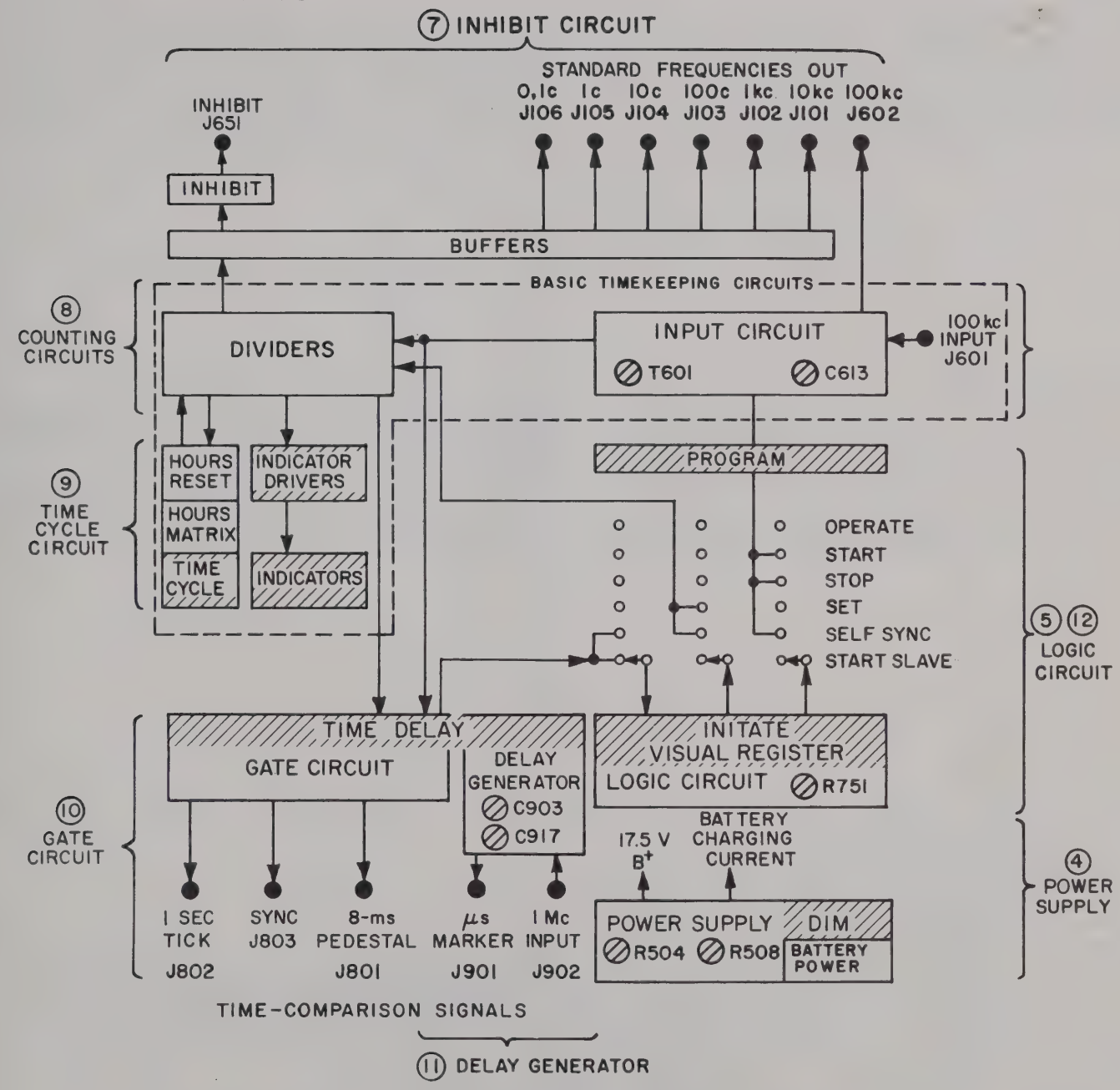
Although the power Supply is not mentioned, it affects the entire operation of the Syncronometer and should be investigated if the checks in this guide prove inconclusive.

Other trouble-shooting aids in this book include:

1. The Operating Procedure (Section 5) — eliminates pilot-error as a source of trouble.
2. The Calibration Procedure (paragraph 5.5) — isolates trouble to a circuit on the board.
3. The schematic diagrams (pages 79 through 105) — contain etched board layouts and additional waveforms and voltages to isolate the trouble to a component or small group of components.

DESCRIPTION	*CIRCUITS INVOLVED*	*ADDITIONAL INFORMATION*		
		Operating Procedure (paragraph)	*Calibration Procedure (paragraph)*	*Schematic Diagram (page)*
TIMEKEEPING. Trouble manifests itself on the visual register.				
Clock won't start (START PROGRAM). Check for 100-kc, 15-V, 6-to-7 μs pulses at 100KC OUT J602; if present, trouble is one of the first five dividers (D1 through D5) or the 1-μs delay network on the inhibit board. The output of each of the five dividers can be monitored at the appropriate STANDARD FREQUENCY OUT connector.	100-kc drive Input circuit Logic circuit Counting circuits Inhibit circuit	2.3 3.3 3.3 3.3 ----	----- 5.5.5 5.5.5 5.5.8 5.5.7	---- 79 81 83 thru 93 103
Some indicators don't count (OPERATE PROGRAM). If only one indicator won't count, the trouble is in the indicator driver for that indicator. If all indicators to the left of a given indicator won't count, the trouble is either the divider for the indicator or the divider for the indicator to its left. A divider is ok if it advances count when the INITIATE button is pushed (SET PROGRAM, VISUAL REGISTER switch set to that indicator).	Counting circuits	----	5.5.8	83 thru 93
Can't set digits on visual register (SET PROGRAM, VISUAL REGISTER switch set to desired indicator). If the clock starts properly and counts properly, the trouble is in the logic circuit.	Logic circuit	3.4.1	5.5.5	81
Can't advance time on visual register (SET PROGRAM, VISUAL REGISTER switch set to OPERATE). If the clock starts properly and counts properly, the trouble is in the logic circuit.	Logic circuit	3.4.2	5.5.5	81
Can't hold time on visual register (SET PROGRAM, VISUAL REGISTER switch set fully clockwise to spring-return position). If the clock starts properly and counts properly, the trouble is in the logic circuit.	Logic circuit	3.4.3	5.5.5	81
Can't stop clock (STOP PROGRAM). If the clock starts properly and counts properly, the trouble is in the logic circuit.	Input circuit Logic circuit	3.3 3.5	5.5.6 5.5.5	79 81
Clock won't cycle. If the clock starts properly and counts properly, the trouble in in the time cycle circuit (hours matrix or hours reset).	Time Cycle circuit	----	5.5.9	95 thru 97
TIME-COMPARISON MEASUREMENTS. Trouble manifests itself on the oscilloscope.				
Unable to make normal-resolution measurements. If timekeeping operation is ok, the trouble is in the gate circuit (assuming the oscilloscope and receiver are ok).	Gate circuit	3.6	5.5.10	99
Unable to make high-resolution measurements. If timekeeping operation is ok and normal-resolution measurements can be made, trouble is either the 1-Mc drive or the delay generator.	1-Mc drive Delay generator	3.7 3.7	----- 5.5.11	---- 101
SYNCHRONIZING AND SLAVING. Trouble manifests itself in the Syncronometer or the external equipment.				
Unable to synchronize itself (SELF SYNC PROGRAM). If timekeeping operation is ok and normal-resolution measurements can be made, trouble is in the Logic circuit.	Logic circuit	3.8.1	5.5.12	81
Unable to slave external equipment (START SLAVE PROGRAM). If timekeeping operation is ok and normal-resolution measurements can be made, trouble is in the logic circuit.	Logic circuit	3.8.2	5.5.12	81

CIRCUIT RELATIONSHIPS



FRONT-PANEL CONTROL OR INDICATOR

ADJUSTMENT

⑤ CALIBRATION-PROCEDURE STEP

1123-40

• 5.5 CALIBRATION PROCEDURE

5.5.1 INTRODUCTION

This procedure can be used for troubleshooting or calibration. If used for troubleshooting, the steps can be performed in any order. If used for calibration, the steps should be performed in the order given because one step serves as a foundation for the next.

The Type 1123-A Digital Syncronometer incorporates the high reliability inherent in conservatively designed, solid-state, digital circuitry, and no routine calibrations are necessary. They may be performed, however, to satisfy government or company policy or one's own curiosity.

5.5.2 PRELIMINARY

Test points are shown on page 61. Most test points are on the bottom of the instrument and all adjustments are on the top; therefore the most convenient position to perform the calibration is with the instrument on its side.

When power is first applied, more than one number per indicator may light up. To prevent possible damage to the indicator circuits in this event, set the VISUAL REGISTER switch to the offending indicator and push the INITIATE button to advance the count until only one number is lit.

If, for any reason, you want the Syncronometer off, be sure to turn the BATTERY POWER switch OFF in addition to removing the power cord.

5.5.3 EQUIPMENT REQUIRED

The following equipment is required for a complete calibration of the instrument. The specifications given for this equipment are those necessary for the calibration of the Type 1123-A and are not necessarily those of the suggested equipment.

Metered autotransformer	Output: 90 to 130V (or 180 to 260V), 32W. Meter: Ac, same range as Output voltage, ±3% accuracy. The Type W5MT3W Metered Variac® Autotransformer can be used.
Voltmeter	Range: 0.1 to 20V, dc, ±3% accuracy. Impedance: At least 20,000 ohms per volt. The Type 1806 Electronic Voltmeter can be used.
Current probe	Range: 100 to 600 mA, dc; ±10% accuracy.
Pulse generator	Prf: 3 c/s to 30 kc/s, ±50% accuracy. Duration: 2 to 5 μs, ±20% accuracy. Rise time: 0.5 μs or less. Amplitude: +15V p-to-p, ±20% accuracy. The Type 1217 or 1398 Pulse Generators can be used.

100-kc drive source	Frequency: 100 kc/s. Amplitude: 0.5V into 2 kΩ. The Type 1115-B Standard Frequency Oscillator can be used (provides both the 100-kc and 1-Mc drive signals).
1-Mc drive source	Frequency: 1Mc/s, coherent with 100-kc drive signal. Amplitude: 0.5V into 500 Ω. The Type 1115-B Standard Frequency Oscillator can be used (provides both the 100-kc and 1-Mc drive signals).
Dual-trace oscilloscope	Sensitivity: 2 to 5 V/cm, ±3% accuracy, dc coupled. Bandwidth: 15 Mc/s. Rise time: 23 ns. Sweep rate: 1 s to 0.1 μs/cm.
Time-mark generator	Time marks: 1 s to 0.1 μs. Amplitude: 0.2 to 0.5 V, p-to-p, into 1 MΩ. If the Type 1123-A is operating properly, the STANDARD FREQUENCIES OUT can be used as time marks. The use of a time-mark generator is optional. When it is used, the accuracy of the time measurements is dependent on the accuracy of the time-mark generator (typically 0.001%) rather than on the accuracy of the oscilloscope time-base (typically 3%).
20-kΩ potentiometer	Non-inductive (carbon).
Board extenders	15-pin, 4215-2016 18-pin, 4215-2019 24-pin, 4215-2025 Supplied as standard accessories with the Syncronometer.

5.5.4 POWER SUPPLY

All of the circuits in the instrument depend on the power supply for proper operation; therefore it is checked first. The power supply provides two main outputs, +17.5 volts B+ and 100 to 150 milliamperes battery-charging current.

+17.5 VOLTS

R504 Connect a voltmeter to terminal 111R of the PROGRAM switch, turn the BATTERY POWER switch OFF, and adjust R504 for +17.5V. Check for +17.5V at 90V ac line (or 180V) and at 130V ac line (or 260V). Return to norminal line voltage.

BATTERY-CHARGING CURRENT

R508 Disconnect the red lead from the + terminal of the battery and ground the lead. Turn the BATTERY POWER switch ON and adjust R508 for 600 mA, using a current probe (do not use an ammeter as its internal resistance will upset the circuit).

R504 Turn the BATTERY POWER switch OFF and reconnect the red lead to the + terminal of the battery. Turn the BATTERY POWER switch ON and monitor the current in the red lead with a current probe; the charging current must slowly decrease to 200 mA or less. Continue to monitor the charging current for 30 to 40 minutes; if it drops below 100 mA, readjust R504 to bring it above 100 mA. The object is to maintain a trickle charge of 100 to 150mA when the battery is fully charged.

5.5.5 LOGIC CIRCUIT (part 1)

The Logic Circuit contains four pulse generators which provide control pulses to all other circuits in the instrument. Three of these generators must be operating properly before the rest of the instrument can be checked. The fourth generator is calibrated last because its operation depends on the input, counting, and gate circuits which have not yet been checked.

ZERO-SET VOLTAGE

Turn the PROGRAM switch to any position except OPERATE, connect a voltmeter to SO701-Z22, and check for less than 0.2V (saturation voltage of Q708).

OPERATE PROGRAM initiate pulse generator

100-kc drive : disconnected

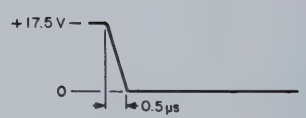
Push the INITIATE button and check for the proper waveform each time the button is pushed.

100-kc drive : disconnected

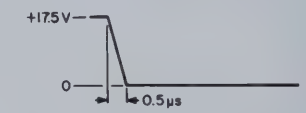
Pulse generator ; 1 kc/s, 5 μs, +15V, connect to SO701-X20 (simulates INITIATE pulses).

Check for proper amplitude in all settings of the PROGRAM switch.

MANUAL INITIATE PULSE
SO701-S15
SCOPE: INTERNAL TRIGGER



SIMULATED
INITIATE PULSE
SO701-S15
SCOPE: INTERNAL TRIGGER



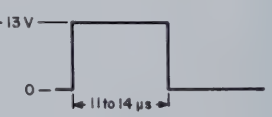
START PROGRAM , start pulse generator

100-kc drive : disconnected

Pulse generator: 1 kc/s, 5 μs, +15V, connect to SO701-X20.

Check for the proper amplitude and duration in the START setting of the PROGRAM switch. Check for no output at all other settings.

START PULSE
GENERATOR OUTPUT
SO701-L10
SCOPE: INTERNAL TRIGGER



STOP PROGRAM, zero pulse generator

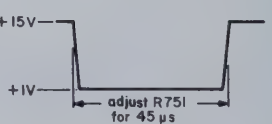
100-kc drive : disconnected

Pulse generator: 1 kc/s, 5 μs, +5V, connect to SO701-X20.

Set the PROGRAM switch to STOP and adjust R751 (located on top of the logic board) for a 45-μs pulse duration. Check for the proper amplitude and duration in the STOP and SELF SYNC positions of the PROGRAM switch. Check for no output at all other settings.

R751

ZERO-PULSE-
GENERATOR OUTPUT
SO701-K9
SCOPE: + EXTERNAL TRIGGER
FROM SO701-S15



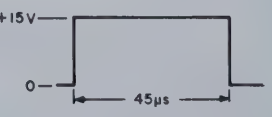
STOP PROGRAM, zero-set pulse generator

100-kc drive : disconnected

Pulse generator: 1 kc/s, 5 μs, +15V, connect to SO701-X20.

Check for the proper amplitude and duration in the STOP and SELF SYNC positions of the PROGRAM switch. Check for no output at all other settings.

ZERO-SET-PULSE
GENERATOR OUTPUT
SO701-Z22
SCOPE: + EXTERNAL TRIGGER
FROM SO701-S15



SET PROGRAM, carry disconnect circuit

100-kc drive: disconnected

Pulse generator: 1 kc/s, 5 μs, +15V, connect to SO701-X20.

Turn the PROGRAM switch to SET and the VISUAL REGISTER switch to SECOND. Push the INITIATE button and check that the dc voltage at SO701-M11 changes from +17.5V to +1.5V. Turn the PROGRAM switch to STOP and check that the voltage returns to +17.5V.

Turn the PROGRAM switch to SET and the VISUAL REGISTER switch to 10 SEC. Push the INITIATE button and check that the voltage drops to +1.5V. Repeat this procedure for all positions of the VISUAL REGISTER switch except OPERATE and HOLD (to return voltage to +17.5V, turn PROGRAM switch to any position except SET).

SELF SYNC PROGRAM, sync pulse generator

Refer to paragraph 5.5.11. This circuit requires an input from circuits not yet checked. It is treated separately later in the procedure.

START SLAVE PROGRAM, sync pulse generator

Refer to paragraph 5.5.11. This circuit requires an input from circuits not yet checked. It is treated separately, later in the procedure.

5.5.6 INPUT CIRCUIT

The input circuit shapes an external, 100-kc, sinewave signal into 100-kc pulses that drive or synchronize all other circuits in the instrument. It also contains a fail-safe feature which stops the clock in the event of an input failure. Since the input circuit is common to all circuits, it is checked early in the procedure.

SENSITIVITY

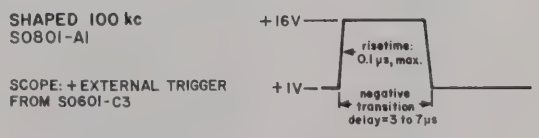
100-kc drive: connected; 20-k pot set for 0.5V p-to-p.

Pulse generator: disconnected.

T601

Display the 100-kc drive signal (SO601-C3 or J601) on the scope and set the 20-kΩ potentiometer for 0.5 V, p-to-p, drive. Then connect the scope to the yellow lead on the input transformer, T601, and adjust T601 for resonance; i.e., adjust T601 for maximum vertical deflection (at least 0.2 V, p-to-p).

Display the shaped 100-kc output (SO801-A1) and check for the proper amplitude, risetime, and negative transition delay. Disconnect the 100-kc drive signal and remove the 20-kΩ pot.

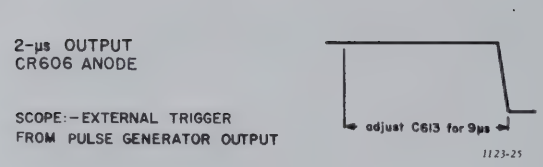


9-μs DELAY CIRCUITS

100-kc drive: disconnected.

Pulse generator: 30 kc/s, 2 μs, +15V, connect to SO701-X20.

C613 Start the clock (set the PROGRAM switch to START and push the INITIATE button) and adjust C613 for the proper delay in the fail-safe loop.



FAIL-SAFE OPERATION

100-kc drive: connected.

Pulse generator: Disconnected.

Start the clock and adjust C613 for the proper delay. Disconnect the 100-kc drive signal; both outputs must disappear. Reconnect the 100-kc drive; both outputs must remain absent. Start the clock; both outputs must reappear.

5.5.7 INHIBIT CIRCUIT

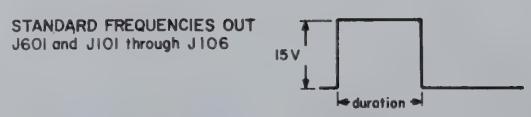
The inhibit-circuit checks are also checks on the operation of the first six dividers in the counting circuits. They are made at this time because the dividers affect the remaining circuits in the instrument.

STANDARD FREQUENCIES OUT, first six dividers, inhibit circuit

100-kc drive: connected.

Start the clock and check for the proper amplitude and duration of the following signals:

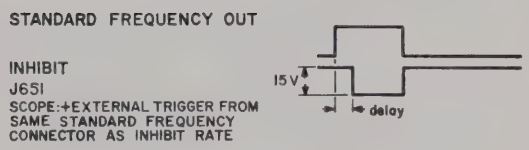
STANDARD	*FREQUENCY*	*Duration*
100 kc	J602	6 to 7 μs
10 kc	J101	16 to 22 μs
1 kc	J102	190 to 210 μs
100 c	J103	2 ms, approx
10 c	J104	20 ms, approx
1 c	J105	200 ms, approx
0.1 c	J106	2 s, approx



INHIBIT PULSE

100-kc drive: connected.

Start the clock and check for the proper amplitude, duration, and delay as follows (characteristics depend on INHIBIT rate; 1-c INHIBIT rate is normally supplied):



INHIBIT Rate	*Internal Connections* *AT1 to*	*AT2 to*	*+ External Scope Trigger from*	*Minimum Delay*	*Duration*
10 kc/s	AT3	AT9	10 kc J101	5μs	20 or 30μs
1 kc/s	AT4	AT3	1 kc J102	50μs	200μs
100 c/s	AT5	AT4	100 c J103	500μs	2ms
10 c/s	AT6	AT5	10 c J104	5ms	20ms
1 c/s	AT7	AT6	1 c J105	50ms	200ms
0.1 c/s	AT8	AT7	0.1 c J106	500ms	2s

5.5.8 COUNTING CIRCUITS

The first six dividers in the counting circuits were checked in the preceeding step. This step checks the last six (one of which, D6, is common to the first six), the indicator drives, and the indicators. Indications of proper operation are taken visually from the indicators, and if a check fails, the trouble can be any one of the three circuits (indicator, driver, or divider) associated with the particular indicator.

COUNT AND CYCLE OPERATION

100-kc drive: disconnected.

Pulse generator: 3 c/s, 5 μs, +15V, connect to SO701-X20.

Turn the PROGRAM switch to SET, the TIME-CYCLE switches to 00, and the VISUAL REGISTER switch to SECOND; the SECOND indicator, I1, must change digits at the same rate as the pulse generator prf, must return to 0 after a count of 9, and must ***not*** cause the next indicator to change (i.e., must count and cycle but must not carry).

Set the VISUAL REGISTER switch to each red-lettered position (10 SEC, MIN, etc); the selected indicator must count and cycle properly and must not carry. The 10 SEC and 10 MIN indicators cycle after a count of 5.

CARRY OPERATION.

100-kc drive: disconnected

Pulse generator: 3 c/s, 5 μs, +15V, connect to SO701-X20.

Set the VISUAL REGISTER switch to OPERATE; the SECOND indicator must count and cycle, as before, and must also carry. Check all indicators for proper count, cycle, and carry operation. The 10 SEC and 10 MIN indicators cycle and carry after a count of 5. Increase the prf of the pulse generator to speed counting.

VISUAL REGISTER TROUBLESHOOTING NOTES

a. If more than one lamp is lit in the same indicator, turn the PROGRAM switch to SET, the VISUAL REGISTER switch to the offending indicator, and push the INITIATE button to advance the count until only one lamp is lit.

b. If no lamp is lit in an indicator, the trouble is probably dirty contacts on the associated indicator driver etched board or a defective lamp.

c. If the lamps light in sequency but an unauthorized lamp lights every other step, the trouble is probably the driver amplifier for that lamp (Q303 through Q318 or Q353 through Q362).

d. If the indicator counts 01, 1, 23, 3, 45, 5, etc, the trouble is probably the odd transistor (Q302, Q306 or Q352, Q356).

e. If the indicator counts 0, 01, 2, 23, 4, 45, etc, the trouble is probably the even transistor (Q301, Q305 or Q351, Q355).

5.5.9 TIME CYCLE CIRCUIT

The time-cycle circuits consist of the hour and 10-hour switches (S402 and S401), the hours matrix circuit, and the hours reset circuit. These circuits operate from inputs supplied by the HOUR and 10 HOUR indicators (D8 and D9) and are checked by applying simulated initiate pulses and observing the HOUR and 10 HOUR indicators.

TIME CYCLE OPERATION

100-kc drive: disconnected

Pulse generator: 30 kc/s, 5 μs, +15V, connect to SO701-X20.

Set the TIME CYCLE switches to 01; the hour indicators must cycle to 00 and stay there. Set the TIME CYCLE switches to 02; the hour indicators must count to 01 and then cycle to 00.

Set the TIME CYCLE switches to 03, 04, 05, 06, 07, 08, and 09; at each setting the hour indicators must count to one less than the TIME CYCLE setting and then cycle to 00; the 10 HOUR indicator must remain at 0.

Set the TIME CYCLE switches to 10, 20, 30, 40, 50, 60, 70, 80, and 90; at each setting the hour indicators must count to one less than the TIME CYCLE setting and then cycle to 00 (i.e., they must count to 09 and then cycle to 00, count to 19 and then cycle to 00, etc.).

5.5.10 GATE CIRCUIT

The gate circuit provides the three outputs necessary for normal-resolution time-comparison measurements. It operates from signals supplied by the input circuit and counting circuits and is checked on an oscilloscope for proper output amplitude, pulse duration, and timing accuracy.

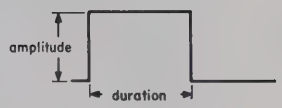
OUTPUTS

100-kc drive: connected
Pulse generator: disconnected

Start the clock and check for the proper amplitude and duration of the following signals:

Output	*Polarity*	*Minimum Amplitude (p-to-p)*	*Duration*
1 SEC TICK J802	positive	13V	4 to 6ms
SYNC J803	positive	13V	5 to 9μs
8ms PEDESTAL J801	positive	7V	6 to 10ms

GATE-CIRCUIT OUTPUT
SCOPE: INTERNAL TRIGGER

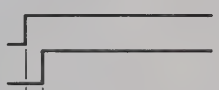


8 ms PEDESTAL, MINIMUM DELAY FROM 1 SEC TICK

100-kc drive: connected
Pulse generator: disconnected

Start the clock, set the TIME DELAY switches to 000 000.0, and check for less than 0.2μs between the leading edge of the 1 SEC TICK and the leading edge of the 8 ms PEDESTAL.

1 SEC TICK
J 802
8ms PEDESTAL
J 801
SCOPE:+EXTERNAL TRIGGER FROM 1 SEC TICK J 801

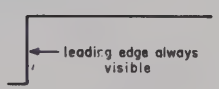


8 ms PEDESTAL, MINIMUM DELAY FROM SYNC

100-kc drive: connected
Pulse generator: disconnected

Start the clock, set the 100μs and 10μs TIME DELAY switches to 0 and vary the 100 ms, 10 ms, and 1 ms TIME DELAY switches through all positions; the leading edge of the 8 ms PEDESTAL must always be visible (the 8 ms PEDESTAL must not start before the SYNC pulse).

SYNC
J 801
SCOPE:+EXTERNAL TRIGGER FROM SYNC J803



5.5.11 DELAY GENERATOR

The μs MARKER output of the Delay Generator supplements the gate-circuit outputs for high-resolution time-comparison measurements. The Delay Generator operates from inputs supplied by the gate circuit and an external 1-Mc signal. It is checked on an oscilloscope for proper amplitude, duration, and timing accuracy.

PHASING, 100 kc/s to 1 Mc/s

100-kc drive: connected
1-Mc drive: connected

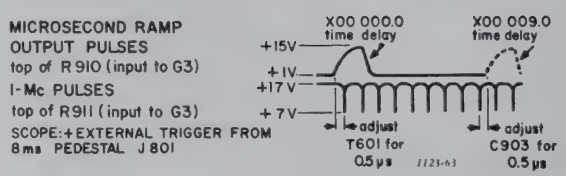
Remove the 100-cycle etched board, D4 (increases the rep rate of the 8 ms PEDESTAL for a brighter scope display) and remove Q905 from the delay generator etched board.

Set the TIME DELAY switches to X00 000.0 and adjust T601 slightly (typically less than one-quarter turn) to position the leading edge of the ramp output pulse exactly 0.5 μs ahead of the first 1-Mc pulse.

T601

Set the TIME DELAY switches to X00 009.0 and adjust C903 to position the leading edge of the ramp output pulse exactly 0.5 μs ahead of the tenth 1-Mc pulse. Replace Q905.

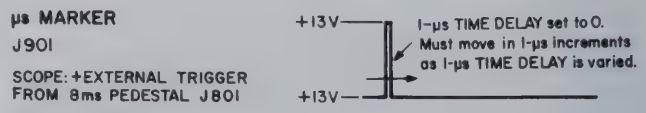
C903



μs MARKER, 1-μs TIMING

100-kc drive: connected
1-Mc drive connected

Check for 11-V minimum amplitude. Vary the 1-μs TIME DELAY switch from 0 to 9; the μs MARKER must move to the right in 1-μs increments, if it does not (stalls or moves more than 1-μs), readjust T601 very slightly and recheck the adjustment of C903 (refer to phasing, previous paragraph).


μs MARKER
J901
SCOPE: +EXTERNAL TRIGGER FROM 8ms PEDESTAL J801
+13V
+13V
1-μs TIME DELAY set to 0.
Must move in 1-μs increments as 1-μs TIME DELAY is varied.

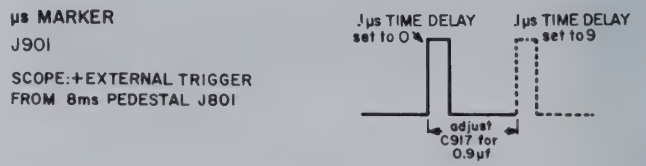
μs MARKER, 0.1-μs TIMING

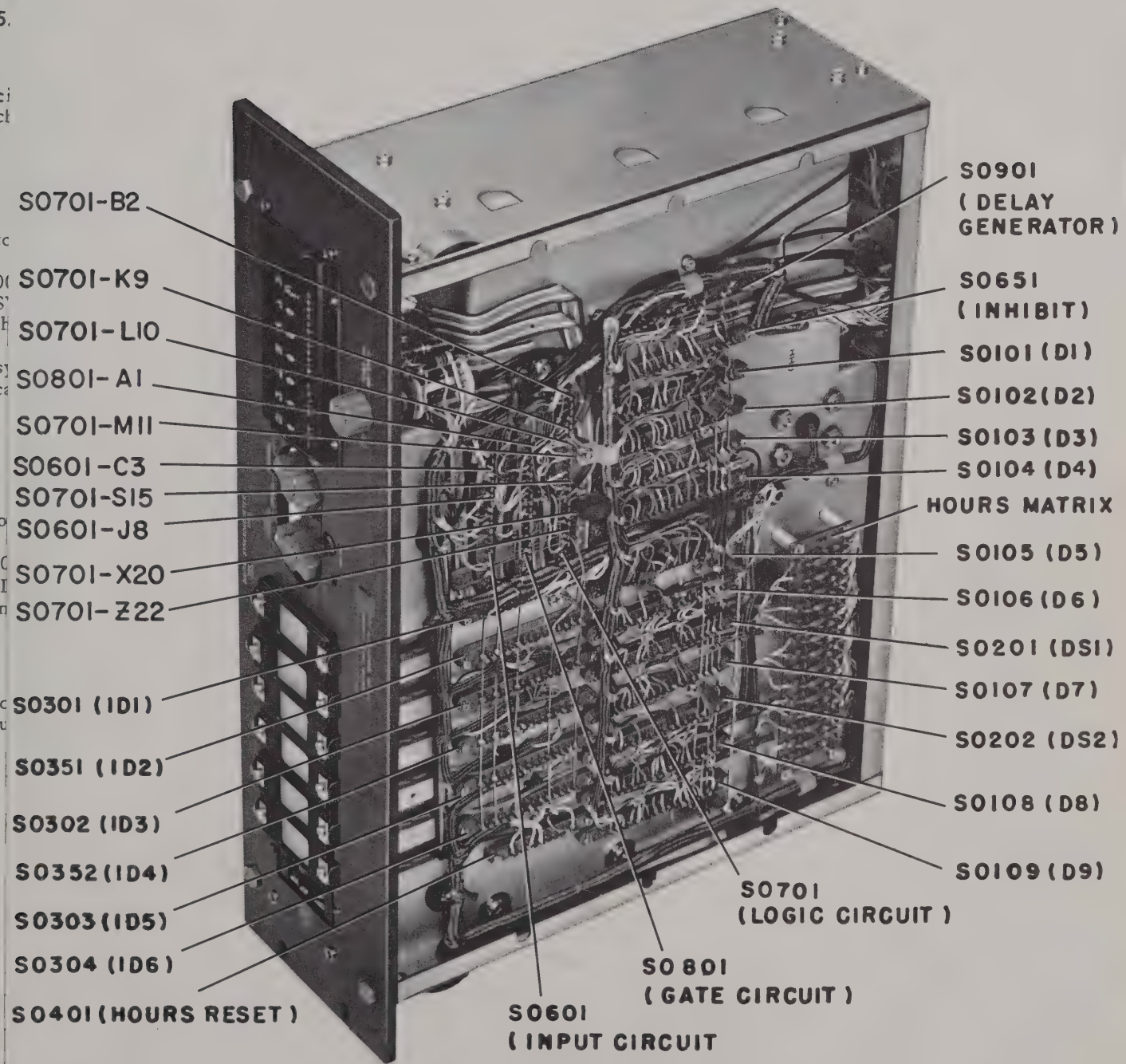
100-kc drive: connected
1-Mc drive: connected

Remove the 100-cycle etched board, D4, if not already removed. Set the .1 μs TIME DELAY dial to .0 and note the position of the leading edge of the μs MARKER. Set the .1 μs TIME DELAY dial to .9 and adjust C917 to position the leading edge of the μs MARKER exactly 9 μs to the right of its original position.

C917

Move the μs MARKER to the left in 0.1-μs increments as noted on the scope display. At each position the .1 μs TIME DELAY dial must read within half a minor division of the correct value. Replace D4.


μs MARKER
J901
SCOPE: +EXTERNAL TRIGGER FROM 8ms PEDESTAL J801
.1μs TIME DELAY set to 0
.1μs TIME DELAY set to 9
adjust C917 for 0.9μs


S0701-B2
S0701-K9
S0701-L10
S0801-A1
S0701-M11
S0601-C3
S0701-S15
S0601-J8
S0701-X20
S0701-Z22
S0301 (ID1)
S0351 (ID2)
S0302 (ID3)
S0352 (ID4)
S0303 (ID5)
S0304 (ID6)
S0401 (HOURS RESET)
S0601
(INPUT CIRCUIT
S0801
(GATE CIRCUIT)
S0701
(LOGIC CIRCUIT)
S0901
(DELAY
GENERATOR)
S0651
(INHIBIT)
S0101 (D1)
S0102 (D2)
S0103 (D3)
S0104 (D4)
HOURS MATRIX
S0105 (D5)
S0106 (D6)
S0201 (DS1)
S0107 (D7)
S0202 (DS2)
S0108 (D8)
S0109 (D9)

5.5.11 DELAY GENERATOR

The μs MARKER output of the Delay Generator supplements the gate-circuit outputs for high-resolution time-comparison measurements. The Delay Generator operates from inputs supplied by the gate circuit and an external 1-Mc signal. It is checked on an oscilloscope for proper amplitude, duration, and timing accuracy.

PHASING, 100 kc/s to 1 Mc/s

100-kc drive: connected
1-Mc drive: connected

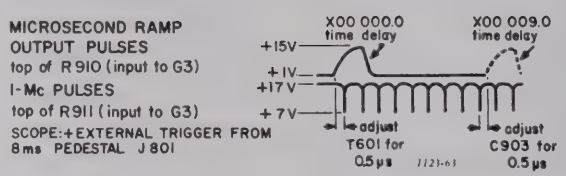
Remove the 100-cycle etched board, D4 (increases the rep rate of the 8 ms PEDESTAL for a brighter scope display) and remove Q905 from the delay generator etched board.

Set the TIME DELAY switches to X00 000.0 and adjust T601 slightly (typically less than one-quarter turn) to position the leading edge of the ramp output pulse exactly 0.5 μs ahead of the first 1-Mc pulse.

T601

Set the TIME DELAY switches to X00 009.0 and adjust C903 to position the leading edge of the ramp output pulse exactly 0.5 μs ahead of the tenth 1-Mc pulse. Replace Q905.

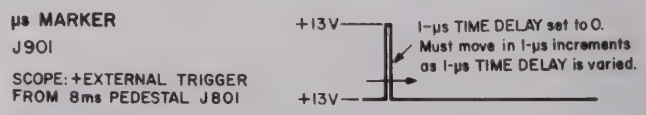
C903



μs MARKER, 1-μs TIMING

100-kc drive: connected
1-Mc drive connected

Check for 11-V minimum amplitude. Vary the 1-μs TIME DELAY switch from 0 to 9; the μs MARKER must move to the right in 1-μs increments, if it does not (stalls or moves more than 1-μs), readjust T601 very slightly and recheck the adjustment of C903 (refer to phasing, previous paragraph).



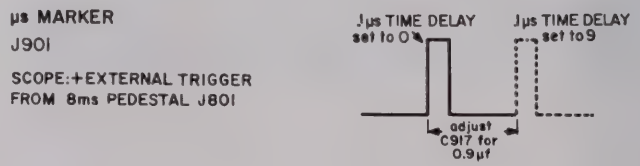
μs MARKER, 0.1-μs TIMING

100-kc drive: connected
1-Mc drive: connected

Remove the 100-cycle etched board, D4, if not already removed. Set the .1 μs TIME DELAY dial to .0 and note the position of the leading edge of the μs MARKER. Set the .1 μs TIME DELAY dial to .9 and adjust C917 to position the leading edge of the μs MARKER exactly 9 μs to the right of its original position.

C917

Move the μs MARKER to the left in 0.1-μs increments as noted on the scope display. At each position the .1 μs TIME DELAY dial must read within half a minor division of the correct value. Replace D4.



5.5.12 LOGIC CIRCUIT (part 2)

Three of the four pulse generators in the logic circuit were checked earlier in this procedure. This step checks the remaining generator.

SELF SYNC PROGRAM, sync pulse generator

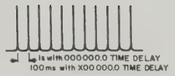
100-kc drive: disconnected

Pulse generator : 10 c/s, 5 μs, +15V, connect to SO701-X20.

Start the clock, set the TIME DELAY switches to 000 000.0, and turn the PROGRAM switch to SELF SYNC; the sync pulse generator prf must be 1 c/s and the indicators must be counting.

Set the TIME DELAY switches to X00 000.0; the sync pulse generator prf must be *10 c/s* and the indicators must *not* be counting.

SYNC PULSE GENERATOR OUTPUT
SO701-B2
SCOPE: INTERNAL TRIGGER



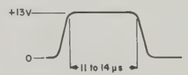
START SLAVE PROGRAM.

100-kc drive: disconnected

Pulse generator: 10 c/s, 5 μs, +15V, connect to SO701-X20.

Start the clock, set the TIME DELAY switches to 000 000.0, and turn the PROGRAM switch to START SLAVE. Check the START pulse for the proper duration and amplitude.

START PULSE
J701
SCOPE: INTERNAL TRIGGER

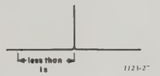


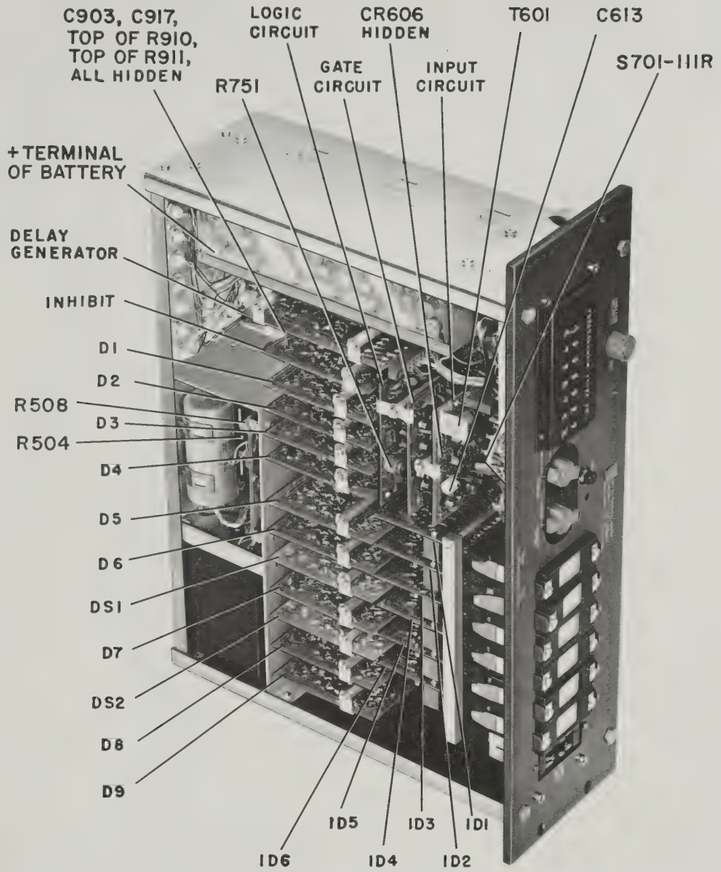
100-kc drive: connected

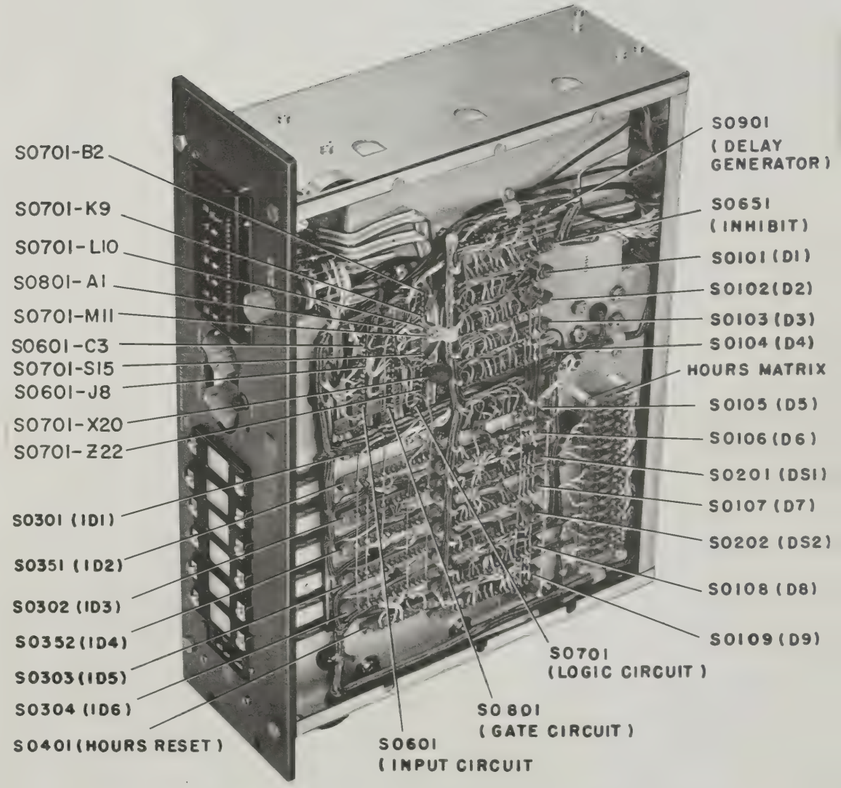
Pulse generator: disconnected

Push the INITIATE button; the START pulse must occur within one second after the INITIATE button is pushed.

START PULSE
J701
SCOPE: +EXTERNAL TRIGGER FROM SO701-S15







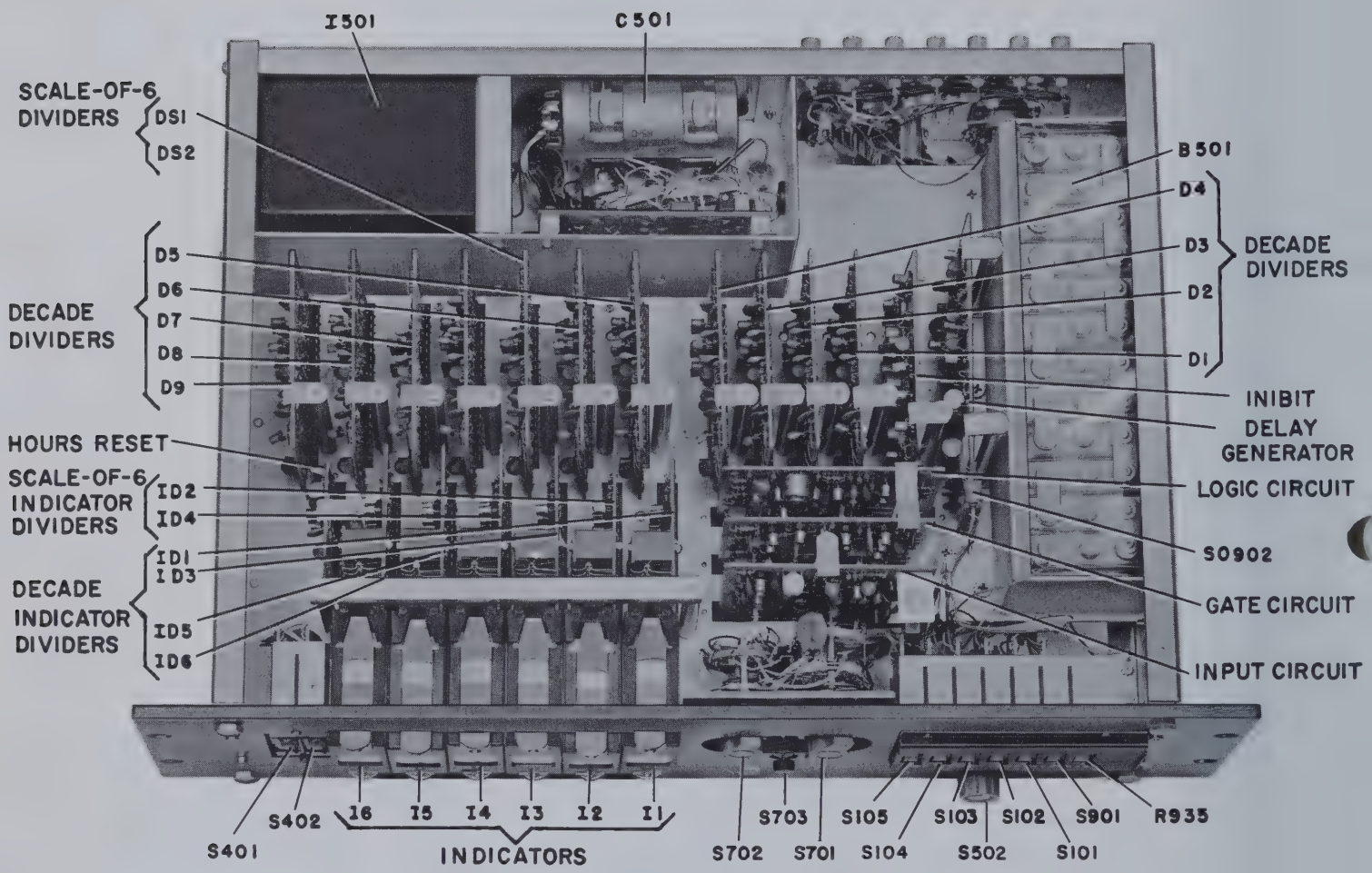
SECTION 6 PARTS LIST AND SCHEMATICS

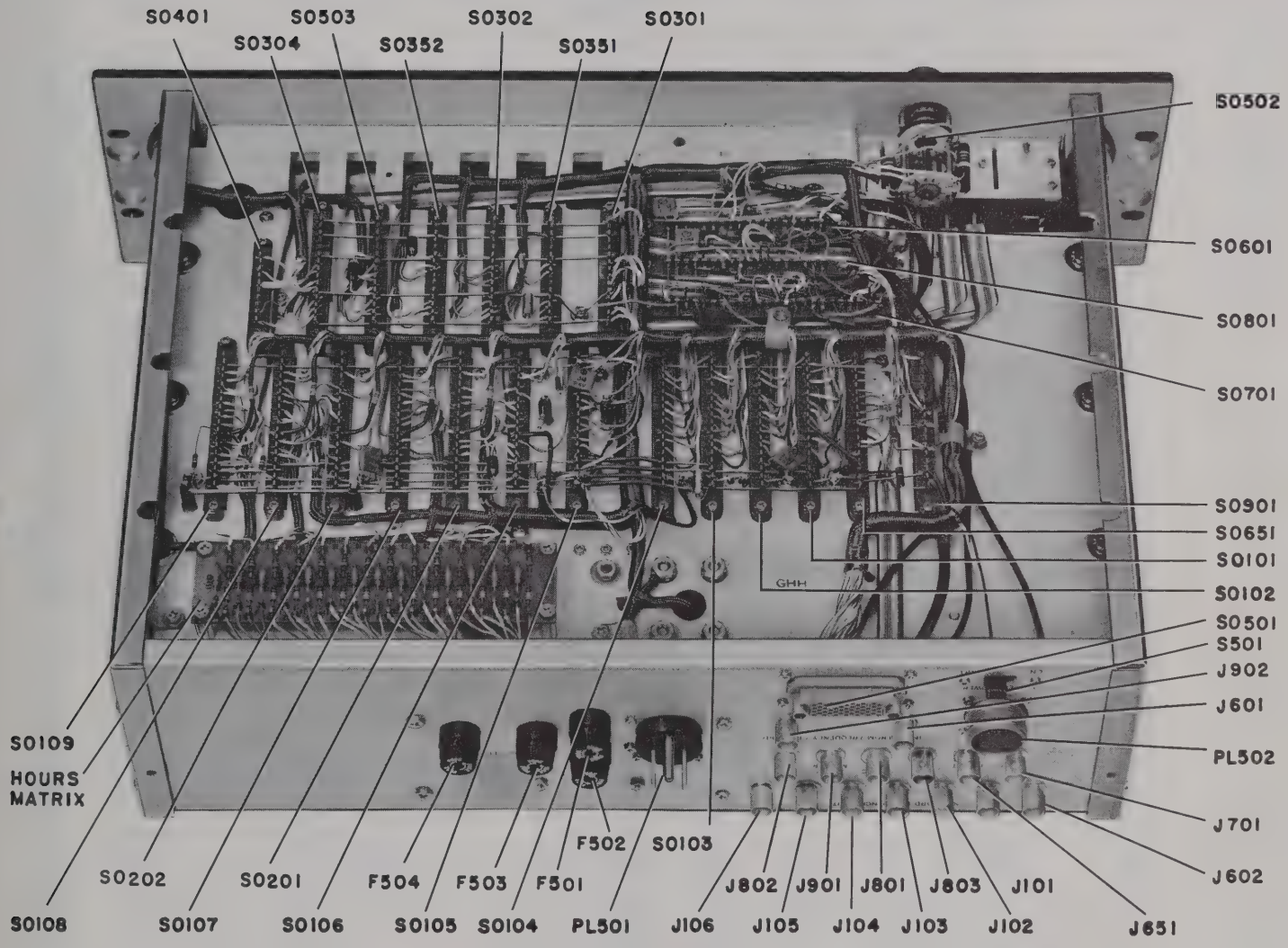
Type 1123-A and Type 1123-AD (formerly 1123-AS1) divider boards are interchangeable.

If interchanged, the DATA OUTPUT may be unusable, however, because the Type 1123-A dividers provide 1-2-4-2 output coding and the Type 1123-AD dividers provide 1-2-4-8 output coding and lower output impedance.

CONTENTS

Schematic	*Part Number of etched-board assembly*	*Number of boards used*	*Reference number series*	*Page*
Logic Diagram	———	–	—	73
Interconnections	———	–	—	75, 77
Input Circuit	1123-4760	1	600	79
Logic Circuit	1123-4770	1	700	81
Type 1123-A Decade Divider	1123-4710	9	100	83
Type 1123-AD Decade Divider	1123-4715	9	100	85
Type 1123-A Scale-of-6 Divider	1123-4720	2	200	87
Type 1123 AD Scale-of-6 Divider	1123-4725	2	200	89
Decade Indicator Driver	1123-4730	4	300	91
Scale-of-6 Indicator Driver	1123-4735	2	350	93
Hours Matrix	1123-2745	1	450	95
Hours Reset	1123-4740	1	400	97
Gate Circuit	1123-4780	1	800	99
Delay Generator	1123-4790	1	900	101
Inhibit Circuit	1123-4765	1	650	103
Power Supply	———	–	500	105


I501
C501
SCALE-OF-6 DIVIDERS
DS1
DS2
DECADE DIVIDERS
D5
D6
D7
D8
D9
HOURS RESET
SCALE-OF-6 INDICATOR DIVIDERS
ID2
ID4
DECADE INDICATOR DIVIDERS
ID1
ID3
ID5
ID6
B501
D4
D3
D2
D1
DECADE DIVIDERS
INIBIT DELAY GENERATOR
LOGIC CIRCUIT
S0902
GATE CIRCUIT
INPUT CIRCUIT
S402
I6
I5
I4
I3
I2
I1
S703
S105
S103
S102
S901
R935
S401
INDICATORS
S702
S701
S104
S502
S101


S0401
S0503
S0304
S0352
S0302
S0351
S0301
S0502
S0601
S0801
S0701
S0901
S0651
S0101
S0102
S0501
S501
J902
J601
PL502
J701
J602
J651
S0109
HOURS
MATRIX
S0202
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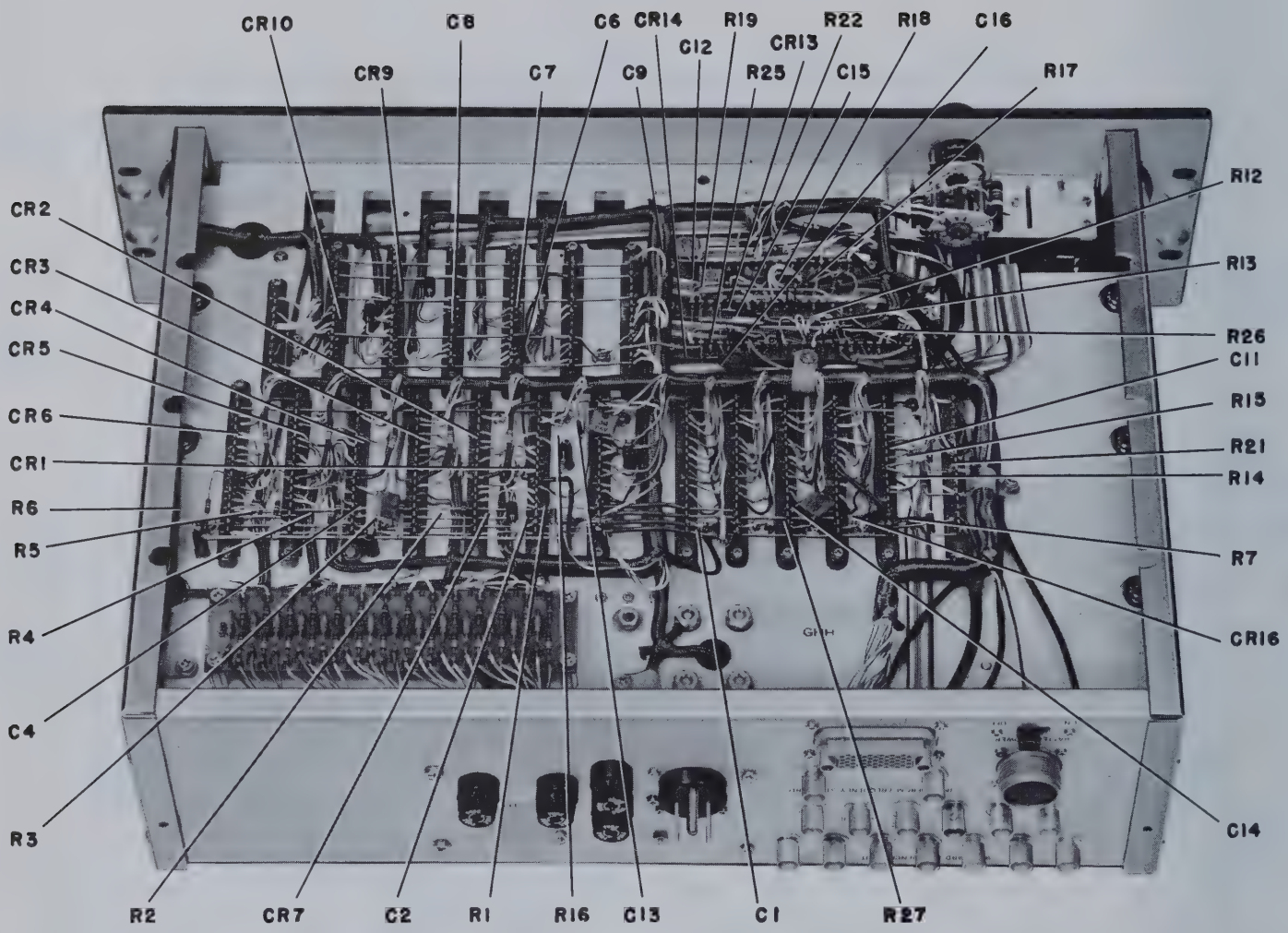
F503
F501
F502
S0103
S0108
S0107
S0106
S0105
S0104
PL501
J106
J105
J104
J103
J102
J802
J901
J801
J803
J101
GHH


CR10
C8
C6
CR14
R19
R22
R18
C16
C12
CR13
CR9
C7
C9
R25
C15
R17
R12
CR2
CR3
R13
CR4
R26
CR5
C11
CR6
R15
CR1
R21
R14
R6
R5
R7
CR16
R4
C4
R3
C14
R2
CR7
C2
R1
R16
C13
C1
R27

PARTS LIST

REF NO.	DESCRIPTION	PART NO.
BATTERY B501	12-cell, explosion-proof, nickel cadmium	8410-1060
BEZEL	Front-panel bezel	1123-8100
CAPACITORS		
C1	Electrolytic, 6.8 µF ±20% 35V	4450-5000
C2	Electrolytic, 6.8 µF ±20% 6V	4450-4800
C3	Electrolytic, 6.8 µF ±20% 6V	4450-4800
C4	Ceramic, 0.47 µF ±20% 25V	4400-2054
C5	Electrolytic, 6.8 µF ±20% 35V	4450-5000
C6	Electrolytic, 6.8 µF ±20% 35V	4450-5000
C7	Electrolytic, 6.8 µF ±20% 6V	4450-4800
C8	Electrolytic, 6.8 µF ±20% 6V	4450-4800
C9	Ceramic, 1 µF ±20% 25V	4400-2070
C10	Ceramic, 0.001 µF ±10% 500V	4405-2108
C11	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C12	Ceramic, 1 µF ±20% 25V	4400-2070
C13	Ceramic, 0.1 µF ±20% 25V	4400-2050
C14	Ceramic, 1 µF ±20% 25V	4400-2070
C15	Electrolytic, 47 µF ±20% 6V	4450-5500
C16	Ceramic, 0.01 µF +80-20% 500V	4406-3109
C17	Ceramic, 0.1 µF ±20% 50V	4403-4100
C18	Ceramic, 1 µF ±20% 25V	4400-2070
C101 thru C108	Ceramic, 100 pF ±10% 500V	4404-1108
C109	Ceramic, 120 pF ±10% 500V	4404-1128
C110	Ceramic, 120 pF ±10% 500V	4404-1128
C111	Ceramic, 27 pF ±10% 500V	4404-0398
C112	Ceramic, 47 pF ±10% 500V	4404-0478
C113	Ceramic, 47 pF ±10% 500V	4404-0478
C114	Ceramic, 47 pF ±10% 500V	4404-0478
C115	Ceramic, 0.001 µF ±10% 500V	4405-2108
C116	Ceramic, 22 pF ±10% 500V	4404-0228
C117	Ceramic, 47 pF ±10% 500V	4404-0478
C118	Ceramic, 47 pF ±10% 500V	4404-0478
C119	Ceramic, 0.0047 µF +80-20% 500V	4405-2479
*C119	Ceramic, 0.0047 µF ±20% 500V	4405-2470
C120	Ceramic, 20 pF ±10% 500V	4404-0208
C121	Trimmer, 7 to 25 pF 350V	4910-3032
C122	Trimmer, 7 to 25 pF 350V	4910-3032
C123	Ceramic, 20 pF ±10% 500V	4404-0208
C201 thru C208	Ceramic, 100 pF ±10% 500V	4404-1108
C209	Ceramic, 120 pF ±10% 500V	4404-1128
C211	Ceramic, 27 pF ±10% 500V	4404-0398
C212	Ceramic, 47 pF ±10% 500V	4404-0478
C213	Ceramic, 47 pF ±10% 500V	4404-0478
C215	Ceramic, 0.001 µF ±10% 500V	4404-2108
C216	Ceramic, 22 pF ±10% 500V	4404-0228
C217	Ceramic, 47 pF ±10% 500V	4404-0478
C219	Ceramic, 0.0047 µF +80-20% 500V	4405-2479
*C219	Ceramic, 0.0047 µF ±20% 500V	4405-2470
C220	Ceramic, 20 pF ±10% 500V	4404-0208
C221	Ceramic, 20 pF ±10% 500V	4404-0208
C223	Ceramic, 20 pF ±10% 500V	4404-0208
C401	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C402	Ceramic, 0.001 µF ±10% 500V	4405-2108
C403	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C404	Ceramic, 0.01 µF +80-20% 50V	4401-3100
C405	Ceramic, 1 µF ±20% 25V	4400-2070
C501	Electrolytic, 600, 300, 300 µF 50V	4450-5606
C502	Ceramic, 0.001 µF ±10% 500V	4405-2108
C601	Mica, 0.1 µF ±1% -40 to -50 ppm 500V	4560-0301
C602	Ceramic, 47 pF ±10% 500V	4404-0478
C603	Ceramic, 68 pF ±10% 500V	4404-0688
C604	Ceramic, 68 pF ±10% 500V	4404-0688
C605	Ceramic, 68 pF ±10% 500V	4404-0688
C606	Ceramic, 68 pF ±10% 500V	4404-0688
C607	Ceramic, 120 pF ±10% 500V	4404-1128
C608	Ceramic, 100 pF ±10% 500V	4404-1108
C609	Ceramic, 68 pF ±10% 500V	4404-0688
C610	Ceramic, 68 pF ±10% 500V	4404-0688
C611	Ceramic, 68 pF ±10% 500V	4404-0688
C612	Ceramic, 68 pF ±10% 500V	4404-0688
C613	Ceramic, 100 pF ±10% 500V	4404-1108
C614	Ceramic, 47 pF ±10% 500V	4404-0478
C615	Ceramic, 68 pF ±10% 500V	4404-0688
C616	Ceramic, 0.001 µF ±10% 500V	4405-2108
C651	Ceramic, 6.8 pF ±10% 500V	4400-0800
C652	Ceramic, 0.001 µF ±10% 500V	4405-2108
C653	Ceramic, 39 pF ±10% 500V	4404-0398
C654	Ceramic, 100 pF ±10% 500V	4404-1108
C655	Ceramic, 47 pF ±10% 500V	4404-0478
C656	Ceramic, 22 pF ±10% 500V	4404-0228
C701	Ceramic, 0.001 µF ±10% 500V	4405-2108
C702	Ceramic, 100 pF ±10% 500V	4404-1108
C703	Ceramic, 220 pF ±10% 500V	4404-1228
C704	Ceramic, 68 pF ±10% 500V	4404-0688
C705	Ceramic, 68 pF ±10% 500V	4404-0688
C706	Ceramic, 68 pF ±10% 500V	4404-0688
C707	Ceramic, 680 pF ±10% 500V	4405-1688
C708	Ceramic, 68 pF ±10% 500V	4404-0688
C709	Ceramic, 0.001 µF ±10% 500V	4405-2108
C710	Ceramic, 220 pF ±10% 500V	4404-1228
C711	Ceramic, 330 pF ±10% 500V	4404-1338
C712 thru C718	Ceramic, 68 pF ±10% 500V	4404-0688
C719	Ceramic, 0.001 µF ±10% 500V	4405-2108
C801	Ceramic, 100 pF ±10% 500V	4404-1108
C802	Ceramic, 220 pF ±10% 500V	4404-1228
C803	Ceramic, 47 pF ±10% 500V	4404-0478
C806	Ceramic, 47 pF ±10% 500V	4404-0478
C807	Ceramic, 0.1 µF ±20% 25V	4400-2050
C808	Ceramic, 68 pF ±10% 500V	4404-0688
C809	Ceramic, 0.001 µF ±10% 500V	4405-2108
C810	Ceramic, 100 pF ±10% 500V	4404-1108
C811	Ceramic, 0.001 µF ±10% 500V	4405-2108
C812	Ceramic, 20 µF ±10% 500V	4404-0208
C813	Ceramic, 120 pF ±10% 500V	4404-1128
C814	Ceramic, 0.1 µF ±20% 25V	4400-2050
C815	Ceramic, 0.001 µF ±10% 500V	4405-2108
C816	Ceramic, 0.001 µF ±10% 500V	4405-2108
C818	Ceramic, 68 pF ±10% 500V	4404-0688
C901	Ceramic, 68 pF ±10% 500V	4404-0688
C902	Ceramic, 75 pF ±5% 500V	4404-0755
C903	Trimmer, 7 to 25 pF 350V	4910-2032
C904	Ceramic, 68 pF ±10% 500V	4404-0688
C905	Ceramic, 47 pF ±10% 500V	4404-0478
C906	Ceramic, 47 pF ±10% 500V	4404-0478
C907	Ceramic, 68 pF ±10% 500V	4404-0688
C908	Ceramic, 68 pF ±10% 500V	4404-0688
C909	Ceramic, 68 pF ±10% 500V	4404-0688
C910	Ceramic, 47 pF ±10% 500V	4404-0478
C911	Ceramic, 330 pF ±10% 500V	4404-1338
C912	Ceramic, 330 pF ±10% 500V	4404-1338
C913	Ceramic, 39 pF ±10% 500V	4404-0398
C914	Ceramic, 330 pF ±10% 500V	4404-1338
C915	Ceramic, 47 pF ±10% 500V	4404-0478
C916	Ceramic, 39 pF ±10% 500V	4404-0398
C917	Trimmer, 7 to 25 pF 350V	4910-2032
C918	Ceramic, 27 pF ±10% 500V	4404-0278
C919	Ceramic, 68 pF ±10% 500V	4404-0688
C920	Ceramic, 27 pF ±10% 500V	4404-0278
C921	Ceramic, 22 pF ±10% 500V	4404-0228
C922	Ceramic, 1 µF ±20% 25V	4400-2070
C923	Ceramic, 1 µF ±20% 25V	4400-2070
C924	Ceramic, 0.02 µF +80-20% 50V	4402-3200

* TYPE 1123-AD

PARTS LIST

REF NO.	DESCRIPTION	PART NO.
DIODES		
CR1 thru CR6	Type 1N625	6082-1012
CR7	Type 1N3253	6082-1001
CR8	Type 1N645	6082-1016
CR9	Type 1N3253	6082-1001
CR10	Type 1N3253	6082-1001
CR11	Type 1N645	6082-1016
CR12	Type 1N645	6082-1016
CR13	Type 1N645	5082-1016
CR14	Type 1N645	6082-1016
CR15	Type 1N625	6082-1012
CR16	Type 1N645	6082-1016
CR101 thru CR111	Type 1N625	6082-1012
CR201 thru CR211	Type 1N625	6082-1012
CR451 thru CR464	Type 1N625	6082-1012
CR501 thru CR504	Type 1N1613	6082-1012
CR505	Type 1N3253	6081-1001
CR506	Type 1N3253	6081-1001
CR507	Tvpe 1N941	6083-1013
CR508	Type 1N3253	6081-1001
CR601	Type 1N625	6082-1012
CR602	Type 1N625	6082-1012
CR603	Type 1N645	6082-1016
CR604	Type 1N625	6082-1012
CR605	Type 1N645	6082-1016
CR606	Type 1N625	6082-1012
CR607	Type 1N645	6082-1016
CR651	Type 1N625	6082-1012
CR701	Type 1N625	6082-1012
CR702	Type 1N625	6082-1012
CR703	Type 1N625	6082-1012
CR704	Type 1N625	6082-1012
CR705	Type 1N625	6082-1012
CR706	Type 1N625	6082-1012
CR707 thru CR710	Type 1N625	6082-1012
CR801	Type 1N625	6082-1012
CR802	Type 1N625	6082-1012
CR804	Type 1N625	6082-1012
CR805	Type 1N625	6082-1012
CR806	Type 1N645	6082-1016
CR807	Type 1N625	6082-1012
CR901	Type 1N3604	6082-1001
CR902	Type 1N625	6082-1012
CR903	Type 1N625	6082-1012
CR904	Type 1N3604	6082-1001
CR905	Type 1N645	6082-1016
CR906	Type 1N625	6082-1012
CR907	Type 1N645	6082-1016
CR908	Type 1N645	6082-1016
FUSES		
F501	For 115-V operation, 0.6 A For 230-V operation, 0.3 A	5330-1100 5330-0800
F502	For 115-V operation, 0.6 A For 230-V operation, 0.3 A	5330-1100 5330-0800
F503	1A	5330-1400
F504	2A	5330-2000

REF NO.	DESCRIPTION	PART NO.
INDICATORS		
I1 thru I6	Type IND-1803 indicator assemblies, incandescent-lamp operated, include 12 lamps	5437-1853
2 LAP-9 lamps	Number 330, 14 V, 80 mA, size T-1-3/4	
spare lamps	Each indicator contains at least two unused lamps, the left-hand dot and the right-hand dot. Each scale-of-6 indicator (I2 and I4) contain three additional unused lamps, the digits 7, 8, and 9. Therefore there is a total of 21 unused lamps that can be used as spares.	
JACKS		
	All of the following jacks include a mounting nut and a shakeproof lockwasher (thread size is 3/8-32, NEF-2).	
J101	Connector, bnc female — 10kc OUT	4230-2300
J102	Connector, bnc female — 1kc OUT	4230-2300
J103	Connector, bnc female — 100c OUT	4230-2300
J104	Connector, bnc female — 10c OUT	4230-2300
J105	Connector, bnc female — 1c OUT	4230-2300
J106	Connector, bnc female — 0.1c OUT	4230-2300
J601	Connector, bnc female — INPUT FROM 100kc	4230-2300
J602	Connector, bnc female — 100kc OUT	4230-2300
J651	Connector, bnc female — INHIBIT	4230-2300
J701	Connector, bnc female — START	4230-2300
J801	Connector, bnc female — 8m SEC GATE	4230-2300
J802	Connector, bnc female — 1 SEC TICK	4230-2300
J803	Connector, bnc female — SYNC	4230-2300
J901	Connector, bnc female — 1μ SEC MARKER	4230-2300
J902	Connector, bnc female — STANDARD 1 Mc	4230-2300
PLUGS		
PL501	3-terminal power plug assembly	4240-0700
PL502	7-terminal receptacle — EXT BAT	8420-3410
TRANSISTORS		
Q101 thru Q109	Type 2N2713 — 9 EA	8210-1086
Q110	Type 2N708	8210-3089
Q111	Type 2N708	8210-3089
Q112	Type 2N3414	8210-1047
Q113	Type 2N3414	8210-1047
Q114	Type 2N3414	8210-1047
Q115	Type 2N3414	8210-1047
Q201 thru Q209	Type 2N2713 — 9 EA	8210-1086
Q210	Type 2N708	8210-3089
Q211	Type 2N708	8210-3089
Q212	Type 2N3414	8210-1047
Q213	Type 2N3414	8210-1047
Q215	Type 2N3414	8210-1047
Q301 thru Q304	Type 2N2221 — 4 EA	8210-1071
Q305	Type 2N2221	8210-1070
Q306	Type 2N2221	8210-1070
Q307	Type 2N2221	8210-1071
Q308	Type 2N2221	8210-1071
Q309	Type 2N2221	8210-1070
Q310	Type 2N2221	8210-1070
Q311	Type 2N2221	8210-1071
Q312	Type 2N2221	8210-1071
Q313	Type 2N2221	8210-1070
Q314	Type 2N2221	8210-1071
Q315	Type 2N2221	8210-1071
Q316	Type 2N2221	8210-1070
Q317	Type 2N2221	8210-1071
Q318	Type 2N2221	8210-1071
Q319	Type 2N2221	8210-1070
Q351 thru Q354	Type 2N2221 — 4 EA	8210-1071

PARTS LIST

REF NO.	DESCRIPTION	PART NO.
TRANSISTORS		
Q355	Type 2N2221	8210-1070
Q356	Type 2N2221	8210-1070
Q357	Type 2N2221	8210-1071
Q358	Type 2N2221	8210-1071
Q359	Type 2N2221	8210-1070
Q360	Type 2N2221	8210-1070
Q361	Type 2N2221	8210-1071
Q362	Type 2N2221	8210-1071
Q363	Type 2N2221	8210-1070
Q401	Type 2N901	8210-1037
Q402	Type 2N2221	8210-1070
Q403	Type 2N2221	8210-1070
Q501	Type 2N708	8210-3089
Q502	Type 2N696, uses 6070-0207 heat radiator	8210-1033
Q503	Type 2N1702	8210-1065
Q504	Type 2N708	8210-3089
Q505	Type 2N708	8210-3089
Q506	Type 2N1702	8210-1065
Q507	Type 2N1131, uses 5700-1010 heat sink	8210-1025
Q601	Type 2N2713	8210-1086
Q602	Type 2N708	8210-3089
Q603	Type 2N708	8210-3089
Q604	Type 2N3250	8210-1089
Q605 thru Q608	Type 2N3414 —— 4 EA	8210-1047
Q609	Type 2N3638	8210-1096
Q610 thru Q615	Type 2N708 —— 6 EA	8210-3089
Q651	Type 2N2221	8210-1070
Q652	Type 2N1131	8210-1025
Q653	Type 2N2221	8210-1070
Q654	Type 2N1131	8210-1025
Q655	Type 2N2221	8210-1070
Q656	Type 2N1131	8210-1025
Q657	Type 2N2221	8210-1070
Q658	Type 2N1131	8210-1025
Q659	Type 2N2221	8210-1070
Q660	Type 2N1131	8210-1025
Q661	Type 2N2221	8210-1070
Q662	Type 2N1131	8210-1025
Q663	Type 2N708	8210-3089
Q664	Type 2N708	8210-3089
Q665	Type 2N708	8210-3089
Q666	Type 2N708	8210-3089
Q667	Type 2N708	8210-3089
Q668	Type 2N708	8210-3089
Q701 thru Q706	Type 2N2221 —— 6 EA	8210-1070
Q707	Type 2N708	8210-3089
Q708	Type 2N3414	8210-1047
Q709 thru Q713	Type 2N2221 —— 5 EA	8210-1070
Q801	Type 2N2221	8210-1070
Q802	Type 2N2221	8210-1070
Q806	Type 2N2713	8210-1086
Q807	Type 2N2713	8210-1086
Q808	Type 2N2221	8210-1070
Q809	Type 2N708	8210-3089
Q810	Type 2N2713	8210-1086
Q811	Type 2N2713	8210-1086
Q812	Type 2N708	8210-3089
Q813	Type 2N2221	8210-1070
Q814	Type 2N708	8210-3089
Q815	Type 2N708	8210-3089

REF NO.	DESCRIPTION	PART NO.
Q816 thru Q819	Type 2N2221 —— 4 EA	8210-1070
Q901	Type 2N708	8210-3089
Q902	Type 2N3414	8210-1047
Q903 thru Q912	Type 2N708 —— 10 EA	8210-3089
Q913	Type 2N3414	8210-1047
Q914 thru Q918	Type 2N708 —— 5 EA	8210-3089
RESISTORS		
R1 thru R6	Composition, 10kΩ ±5% 1/4w	6099-3105
R7	Composition, 47Ω ±5% 1/2w	6100-0475
R8	Composition, 100kΩ ±10% 1/4w	6099-4109
R9	Composition, 130Ω ±5% 1/4w	6099-1135
R10	Composition, 100kΩ ±10% 1/4w	6099-4109
R11	Composition, 100kΩ ±10% 1/4w	6099-4109
R12	Composition, 100kΩ ±10% 1/4w	6099-4109
R13	Composition, 100kΩ ±10% 1/4w	6099-4109
R14	Composition, 3kΩ ±5% 1/4w	6099-2305
R15	Composition, 10kΩ ±5% 1/4w	6099-3105
R16	Composition, 1kΩ ±10% 1/4w	6099-2109
R17	Composition, 470Ω ±10% 1/4w	6099-1479
R18	Composition, 1kΩ ±10% 1/4w	6099-2109
R19	Composition, 10kΩ ±5% 1/4w	6099-3105
R20	Composition, 47kΩ ±10% 1/4w	6099-3479
R21	Composition, 27Ω ±5% 1/2w	6100-0275
R22	Composition, 470Ω ±10% 1/4w	6099-1479
R23	Composition, 10kΩ ±10% 1/4w	6099-3109
R24	Composition, 100kΩ ±10% 1/4w	6099-4109
R25	Composition, 100kΩ ±10% 1/4w	6099-4109
R26	Composition, 100kΩ ±10% 1/4w	6099-4109
R27	Composition, 22Ω ±5% 1/4w	6099-0225
R28	Composition, 470Ω ±5% 1/4w	6099-1475
R29	Composition, 470Ω ±5% 1/4w	6099-1475
R30	Composition, 470Ω ±5% 1/4w	6099-1475
R31	Composition, 12Ω ±5% 1/4w	6099-0125
R32	Composition, 470Ω ±5% 1/4w	6099-1475
R101	Composition, 100kΩ ±5% 1/4w	6099-4105
R102	Composition, 10kΩ ±5% 1/4w	6099-3105
R103	Composition, 100kΩ ±5% 1/4w	6099-4105
R104	Composition, 10kΩ ±5% 1/4w	6099-3105
R105	Composition, 47kΩ ±5% 1/4w	6099-3475
R106	Composition, 100kΩ ±5% 1/4w	6099-4105
R107	Composition, 100kΩ ±5% 1/4w	6099-4105
R108	Composition, 10kΩ ±5% 1/4w	6099-3105
R109	Composition, 100kΩ ±5% 1/4w	6099-4105
R110	Composition, 10kΩ ±5% 1/4w	6099-3105
R111 thru R114	Composition, 100kΩ ±5% 1/4w	6099-4105
R115	Composition, 10kΩ ±5% 1/4w	6099-3105
R116	Composition, 10kΩ ±5% 1/4w	6099-3105
R117 thru R120	Composition, 100kΩ ± 5% 1/4w	6099-4105
R121	Composition, 10kΩ ±5% 1/4w	6099-3105
R122	Composition, 10kΩ ±5% 1/4w	6099-3105
R123	Composition, 100kΩ ±5% 1/4w	6099-4105
R124	Composition, 100kΩ ±5% 1/4w	6099-4105
R125	Composition, 10kΩ ±5% 1/4w	6099-3105
R126	Composition, 10kΩ ±5% 1/4w	6099-3105
R127 thru R136	Composition, 100kΩ ±5% 1/4w	6099-4105

PARTS LIST

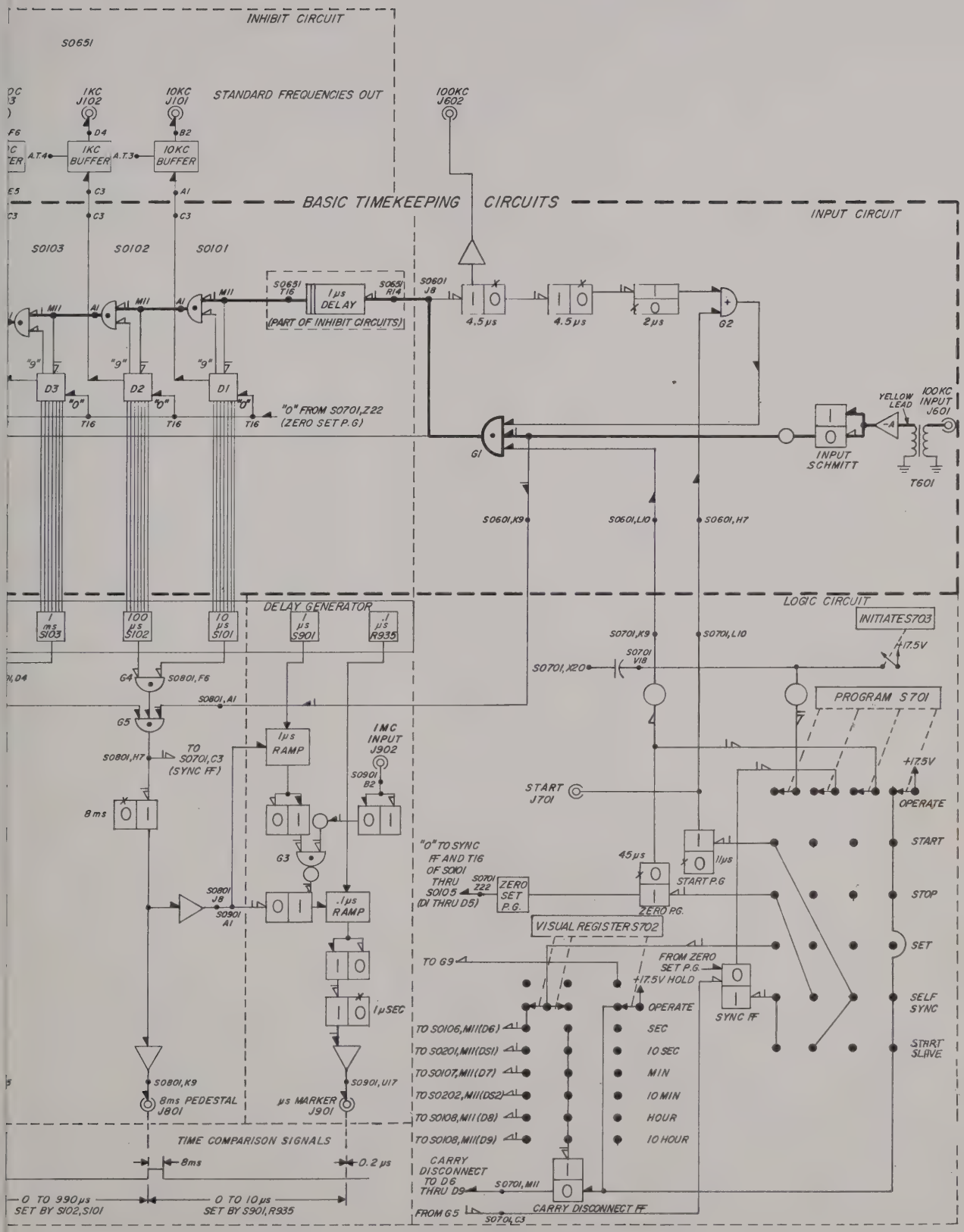
REF NO.	DESCRIPTION	PART NO.
RESISTORS R137 thru R142	Composition, 10kΩ ±5% 1/4w	6099-3105
R143	Composition, 100kΩ ±5% 1/4w	6099-4105
R144	Composition, 47 kΩ ±5% 1/4w	6099-3475
R145 thru R152	Composition, 100kΩ ±5% 1/4w	6099-4105
R153	Composition, 300kΩ ±5% 1/4w	6099-4305
R154	Composition, 150kΩ ±5% 1/4w	6099-4155
R155	Composition, 300kΩ ±5% 1/4w	6099-4305
R156	Composition, 300kΩ ±5% 1/4w	6099-4305
R157	Composition, 300kΩ ±5% 1/4w	6099-4305
R158	Composition, 300kΩ ±5% 1/4w	6099-4305
R159	Composition, 47kΩ ±5% 1/4w	6099-3475
R160	Composition, 47kΩ ±5% 1/4w	6099-3475
R161	Composition, 56kΩ ±10% 1/4w	6099-3565
R162	Composition, 30kΩ ±5% 1/4w	6099-3305
R163	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R164 thru R167	Composition, 10kΩ ±5% 1/4w	6099-3105
R168	Composition, 100kΩ ±5% 1/4w	6099-4105
R169	Composition, 100kΩ ±5% 1/4w	6099-4105
R201	Composition, 100kΩ ±5% 1/4w	6099-4105
R202	Composition, 10kΩ ±5% 1/4w	6099-3105
R203	Composition, 100kΩ ±5% 1/4w	6099-4105
R204	Composition, 10kΩ ±5% 1/4w	6099-3105
R205	Composition, 100kΩ ±5% 1/4w	6099-4105
R207	Composition, 100kΩ ±5% 1/4w	6099-4105
R208	Composition, 10kΩ ±5% 1/4w	6099-3105
R209	Composition, 100kΩ ±5% 1/4w	6099-4105
R210	Composition, 10kΩ ±5% 1/4w	6099-3105
R211	Composition, 100kΩ ±5% 1/4w	6099-4105
R220	Composition, 100kΩ ±5% 1/4w	6099-4105
R221	Composition, 10kΩ ±5% 1/4w	6099-3105
R222	Composition, 10kΩ ±5% 1/4w	6099-3105
R223	Composition, 100kΩ ±5% 1/4w	6 99-4105
R224	Composition, 100kΩ ±5% 1/4w	6099-4105
R225	Composition, 10kΩ ±5% 1/4w	6099-3105
R226	Composition, 10kΩ ±5% 1/4w	6099-3105
R227 thru R231	Composition, 100kΩ ±5% 1/4w	6099-4105
R232	Composition, 10kΩ ±5% 1/4w	6099-3105
R233	Composition, 100kΩ ±5% 1/4w	6099-4105
R234	Composition, 100kΩ ±5% 1/4w	6099-4105
R235	Composition, 100kΩ ±5% 1/4w	6099-4105
R236	Composition, 100kΩ ±5% 1/4w	6099-4105
R237	Composition, 10kΩ ±5% 1/4w	6099-3105
R238	Composition, 10kΩ ±5% 1/4w	6099-3105
R239	Composition, 10k) ±5% 1/4w	6099-3105
R241	Composition, 47kΩ ±5% 1/4w	6099-3475
R242	Composition, 10kΩ ±5% 1/4w	6099-3105
R243	Composition, 100kΩ ±5% 1/4w	6099-4105
R244	Composition, 47kΩ ±5% 1/4w	6099-3475
R245 thru R252	Composition, 100kΩ ±5% 1/4w	6099-4105
R253	Composition, 300kΩ ±5% 1/4w	6099-4305
R254	Composition, 150kΩ ±5% 1/4w	6099-4155
R255	Composition, 300kΩ ±5% 1/4w	6099-4305
R258	Composition, 300kΩ ±5% 1/4w	6099-4305
R261	Composition, 56kΩ ±5% 1/4w	6099-3565
R262	Composition, 30kΩ ±5% 1/4w	6099-3305
R263	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R264	Composition, 10kΩ ±5% 1/4w	6099-3105
R265	Composition, 10kΩ ±5% 1/4w	6099-3105
R267	Composition, 10kΩ ±5% 1/4w	6099-3105
R268	Composition, 100kΩ ±5% 1/4w	6099-4105
R310	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R302	Composition, 6.8 kΩ ±5% 1/4w	6099-2685
R303	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R304	Composition, 300kΩ ±5% 1/4w	6099-4305
R305	Composition, 300kΩ ±5% 1/4w	6099-4305
R306	Composition, 300kΩ ±5% 1/4w	6099-4305
R307	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R308	Composition, 300kΩ ±5% 1/4w	6099-4305
R309	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R310	Composition, 300kΩ ±5% 1/4w	6099-4305
R311	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R312	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R314	Composition, 300kΩ ±5% 1/4w	6099-4305
R351	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R352	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R353	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R354	Composition, 300kΩ ±5% 1/4w	6099-4305
R355	Composition, 300kΩ ±5% 1/4w	6099-4305
R356	Composition, 300kΩ ±5% 1/4w	6099-4305
R357	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R358	Composition, 300kΩ ±5% 1/4w	6099-4305
R359	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R360	Composition, 300kΩ ±5% 1/4w	6099-4305
R401	Composition, 47kΩ ±5% 1/4w	6099-3475
R402	Composition, 10kΩ ±5% 1/4w	6099-3105
R403	Composition, 56kΩ ±5% 1/4w	6099-3565
R404	Composition, 3kΩ ±5% 1/4w	6099-2305
R405	Composition, 100kΩ ±5% 1/4w	6099-4105
R406	Composition, 47kΩ ±5% 1/4w	6099-3475
R407	Composition, 100kΩ ±5% 1/4w	6099-4105
R408	Composition, 2kΩ ±5% 1/4w	6099-2205
R451	Composition, 100kΩ ±5% 1/4w	6099-4105
R452	Composition, 39kΩ ±5% 1/4w	6099-3395
R453	Composition, 100kΩ ±5% 1/4w	6099-4105
R454	Composition, 39kΩ ±5% 1/4w	6099-3395
R455	Composition, 100kΩ ±5% 1/4w	6099-4105
R456	Composition, 39kΩ ±5% 1/4w	6099-3395
R457	Composition, 100kΩ ±5% 1/4w	6099-4105
R458	Composition, 39kΩ ±5% 1/4w	6099-3395
R459	Composition, 100kΩ ±5% 1/4w	6099-4105
R460	Composition, 39kΩ ±5% 1/4w	6099-3395
R461	Composition, 100kΩ ±5% 1/4w	6099-4105
R462	Composition, 39kΩ ±5% 1/4w	6099-3395
R463	Composition, 100kΩ ±5% 1/4w	6099-4105
R464	Composition, 39kΩ ±5% 1/4w	6099-3395
R465	Composition, 100kΩ ±5% 1/4w	6099-4105
R466	Composition, 39kΩ ±5% 1/4w	6099-3395
R467	Composition, 100kΩ ±5% 1/4w	6099-4105
R468	Composition, 39kΩ ±5% 1/4w	6099-3395
R469	Composition, 100kΩ ±5% 1/4w	6099-4105
R470	Composition, 39kΩ ±5% 1/4w	6099-3395
R471	Composition, 100kΩ ±5% 1/4w	6099-4105
R472	Composition, 39kΩ ±5% 1/4w	6099-3395
R473	Composition, 100kΩ ±5% 1/4w	6099-4105
R474	Composition, 39kΩ ±5% 1/4w	6099-3395
R475	Composition, 100kΩ ±5% 1/4w	6099-4105
R476	Composition, 39kΩ ±5% 1/4w	6099-3395
R477	Composition, 100kΩ ±5% 1/4w	6099-4105
R478	Composition, 39kΩ ±5% 1/4w	6099-3395
R501	Composition, 20kΩ ±5% 1/4w	6099-3205
R502	Composition, 620Ω ±5% 1/4w	6099-1625
R503	Precision, 4.02kΩ ±1% 0.3w	6099-1402
R504	Potentiometer, wire-wound, 1kΩ ±10%	6099-2109
R505	Precision, 4.02kΩ ±1% 0.3w	6099-1402
R506	Film, 10kΩ ±1% 1/8w	6250-2100
R507	Composition, 3kΩ ±5% 1/4w	6099-2305
R508	Potentiometer, composition, 50kΩ ±10%	6046-3508
R509	Wire-wound, 2.2Ω ±10% 2w	6760-9229

PARTS LIST

REF NO.	DESCRIPTION	PART NO.
RESISTORS R510 thru R514	Wire-wound, 2.7Ω ±10% 2w	6760-9279
R515	Wire-wound, 4.7Ω ±10% 2w	6760-9479
R516		6740-1602
R517	Film, 3.01kΩ ±1% 1/8w	6250-1301
R601	Composition, 200kΩ ±5% 1/4w	6099-4205
R602	Composition, 120kΩ ±5% 1/4w	6099-4125
R603	Composition, 6.2kΩ ±5% 1/4w	6099-2625
R604	Composition, 6.2kΩ ±5% 1/4w	6099-2625
R605	Composition, 51kΩ ±5% 1/4w	6099-3515
R606	Composition, 30kΩ ±5% 1/4w	6099-3305
R607	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R608	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R609	Composition, 4.3kΩ ±5% 1/4w	6099-2435
R610	Composition, 6.8kΩ ±5% 1/4w	6099-2685
R611	Composition, 10kΩ ±5% 1/4w	6099-3105
R612	Composition, 100kΩ ±5% 1/4w	6099-4105
R613	Composition, 220Ω ±5% 1/4w	6099-1225
R614	Composition, 10kΩ ±5% 1/4w	6099-3105
R615	Composition, 18kΩ ±5% 1/4w	6099-3185
R616	Composition, 3.3kΩ ±5% 1/4w	6099-2335
R617	Composition, 100kΩ ±5% 1/4w	6099-4105
R618	Composition, 100kΩ ±5% 1/4w	6099-4105
R619	Composition, 100kΩ ±5% 1/4w	6099-4105
R620	Composition, 10kΩ ±5% 1/4w	6099-3105
R621	Composition, 100kΩ ±5% 1/4w	6099-4105
R622	Composition, 100kΩ ±5% 1/4w	6099-4105
R623	Composition, 100kΩ ±5% 1/4w	6099-4105
R624	Composition, 10kΩ ±5% 1/4w	6099-3105
R625	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R626	Composition, 100kΩ ±5% 1/4w	6099-4105
R627	Composition, 100kΩ ±5% 1/4w	6099-4105
R628	Composition, 100kΩ ±5% 1/4w	6099-4105
R629	Composition, 330Ω ±5% 1/4w	6099-1335
R630	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R631	Composition, 180Ω ±5% 1/4w	6099-1185
R632	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R633	Composition, 10kΩ ±5% 1/4w	6099-3105
R634	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R635	Composition, 100kΩ ±5% 1/4w	6099-4105
R636	Composition, 100kΩ ±5% 1/4w	6099-4105
R637	Composition, 100kΩ ±5% 1/4w	6099-4105
R638	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R639	Composition, 10kΩ ±5% 1/4w	6099-3105
R640	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R641	Composition, 100kΩ ±5% 1/4w	6099-4105
R642	Composition, 100kΩ ±5% 1/4w	6099-4105
R643	Composition, 100kΩ ±5% 1/4w	6099-4105
R644	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R645	Composition, 2kΩ ±5% 1/4w	6099-2205
R646	Composition, 330Ω ±5% 1/4w	6099-1335
R647	Composition, 51kΩ ±5% 1/4w	6099-3515
R651	Composition, 10kΩ ±5% 1/4w	6099-3105
R652	Composition, 2kΩ ±5% 1/4w	6099-2205
R653	Composition, 150kΩ ±5% 1/4w	6099-1155
R654	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R655	Composition, 10kΩ ±5% 1/4w	6099-3105
R656	Composition, 2kΩ ±5% 1/4w	6099-2205
R657	Composition, 150Ω ±5% 1/4w	6099-1155
R658	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R659	Composition, 10kΩ ±5% 1/4w	6099-3105
R660	Composition, 2kΩ ±5% 1/4w	6099-2205
R661	Composition, 150Ω ±5% 1/4w	6099-1155
R662	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R663	Composition, 10kΩ ±5% 1/4w	6099-3105
R664	Composition, 2kΩ ±5% 1/4w	6099-2205
R665	Composition, 150Ω ±5% 1/4w	6099-1155
R666	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R667	Composition, 10kΩ ±5% 1/4w	6099-3105
R668	Composition, 2kΩ ±5% 1/4w	6099-2205
R669	Composition, 150Ω ±5% 1/4w	6099-1155
R670	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R671	Composition, 10kΩ ±5% 1/4w	6099-3105
R672	Composition, 2kΩ ±5% 1/4w	6099-2205
R673	Composition, 150Ω ±5% 1/4w	6099-1155
R674	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R675	Composition, 100kΩ ±5% 1/4w	6099-4105
R676	Composition, 10kΩ ±5% 1/4w	6099-3105
R677	Composition, 10kΩ ±5% 1/4w	6099-3105
R678	Composition, 10kΩ ±5% 1/4w	6099-3105
R679	Composition, 47 kΩ ±5% 1/4w	6099-3475
R680	Composition, 47kΩ ±5% 1/4w	6099-3475
R681	Composition, 10kΩ ±5% 1/4w	6099-3105
R682	Composition, 10kΩ ±5% 1/4w	6099-3105
R683	Composition, 22kΩ ±5% 1/4w	6099-3225
R684	Composition, 100kΩ ±5% 1/4w	6099-4105
R685	Composition, 1kΩ ±5% 1/2w	6100-2105
R686	Composition, 1kΩ ±5% 1/4w	6099-2105
R687	Composition, 39kΩ ±5% 1/4w	6099-3395
R688	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R689	Composition, 100kΩ ±5% 1/4w	6099-4105
R690	Composition, 10kΩ ±5% 1/4w	6099-3105
R691	Composition, 150kΩ ±5% 1/4w	6099-1155
R701	Composition, 56kΩ ±5% 1/4w	6099-3565
R702	Composition, 100kΩ ±5% 1/4w	6099-4105
R703	Composition, 10kΩ ±5% 1/4w	6099-3105
R704	Composition, 10kΩ ±5% 1/4w	6099-3105
R705	Composition, 100kΩ ±5% 1/4w	6099-4105
R706	Composition, 39kΩ ±5% 1/4w	6099-3395
R707	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R708	Composition, 100kΩ ±5% 1/4w	6099-4105
R709	Composition, 100kΩ ±5% 1/4w	6099-4105
R710	Composition, 100kΩ ±5% 1/4w	6099-4105
R711	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R712	Composition, 1kΩ ±5% 1/4w	6099-2105
R713	Composition, 10kΩ ±5% 1/4w	6099-3105
R714	Composition, 100kΩ ±5% 1/4w	6099-4105
R715	Composition, 10kΩ ±5% 1/4w	6099-3105
R716	Composition, 47kΩ ±5% 1/4w	6099-3475
R717	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R718	Composition, 91kΩ ±5% 1/4w	6099-3915
R719	Composition, 100kΩ ±5% 1/4w	6099-4105
R720	Composition, 100kΩ ±5% 1/4w	6099-4105
R721	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R722	Composition, 100kΩ ±5% 1/4w	6099-4105
R723	Composition, 100kΩ ±5% 1/4w	6099-4105
R724	Composition, 10kΩ ±5% 1/4w	6099-3105
R725	Composition, 47kΩ ±5% 1/4w	6099-3475
R726	Composition, 47kΩ ±5% 1/4w	6099-3475
R727	Composition, 1kΩ ±5% 1/4w	6099-2105
R728	Composition, 100kΩ ±5% 1/4w	6099-4105
R729	Composition, 10kΩ ±5% 1/4w	6099-3105
R730	Composition, 10kΩ ±5% 1/4w	6099-3105
R731	Composition, 100kΩ ±5% 1/4w	6099-4105
R732	Composition, 100kΩ ±5% 1/4w	6099-4105
R733	Composition, 10kΩ ±5% 1/4w	6099-3105
R734	Composition, 10kΩ ±5% 1/4w	6099-3105
R735	Composition, 100kΩ ±5% 1/4w	6099-4105
R736	Composition, 100kΩ ±5% 1/4w	6099-4105
R737	Composition, 10kΩ ±5% 1/4w	6099-3105
R738	Composition, 100kΩ ±5% 1/4w	6099-4105
R739	Composition, 100kΩ ±5% 1/4w	6099-4105
R740	Composition, 100kΩ ±5% 1/4w	6099-4105
R741	Composition, 10kΩ ±5% 1/4w	6099-3105
R742	Composition, 100kΩ ±5% 1/4w	6099-4105
R743	Composition, 10kΩ ±5% 1/4w	6099-3105
R744	Composition, 56kΩ ±5% 1/4w	6099-3565
R745	Composition, 100kΩ ±5% 1/4w	6099-4105
R746	Composition, 100kΩ ±5% 1/4w	6099-4105
R747	Composition, 5.6kΩ ±5% 1/4w	6099-2565
R748	Composition, 5.6kΩ ±5% 1/4w	6099-2565

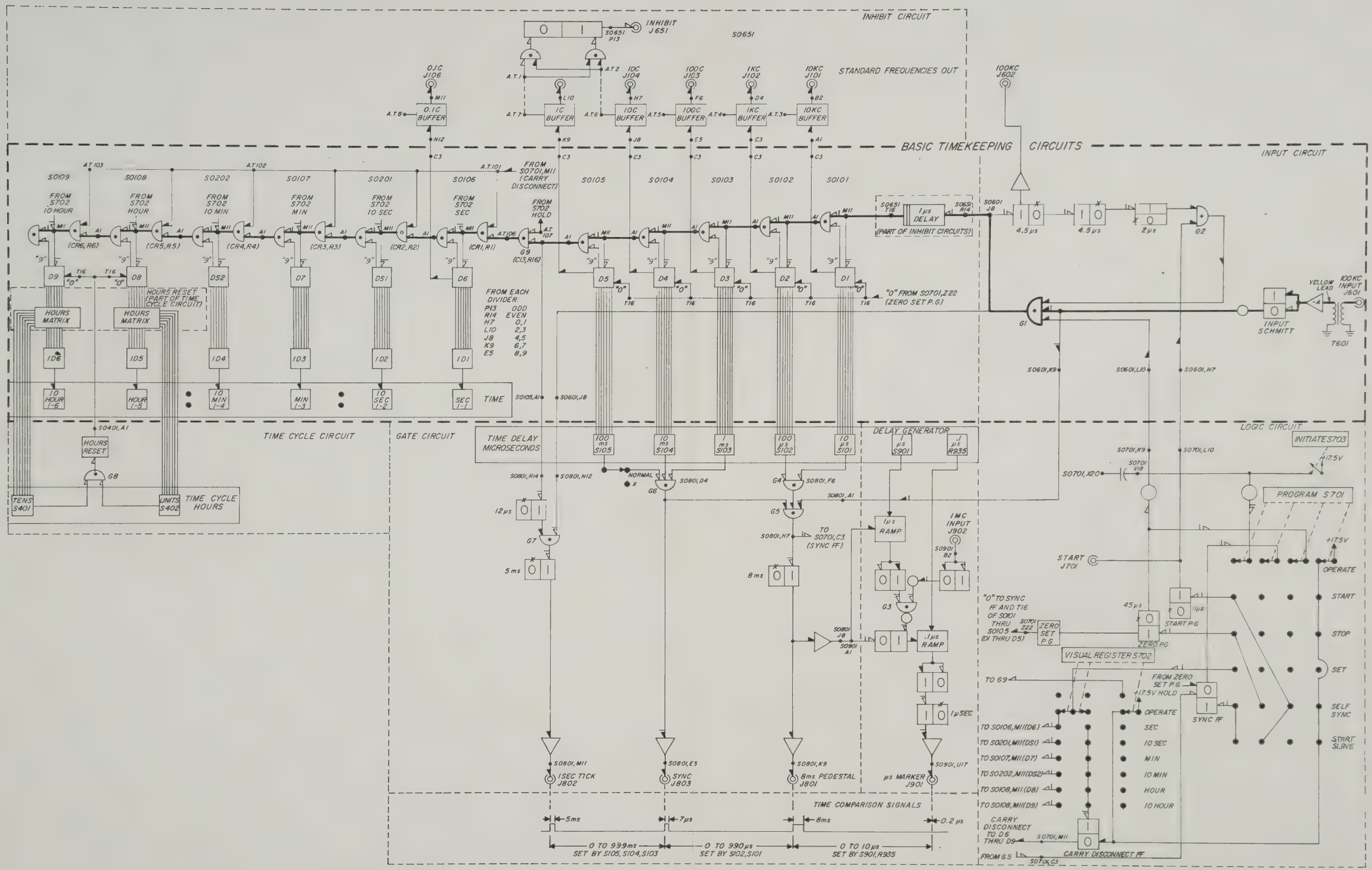
PARTS LIST

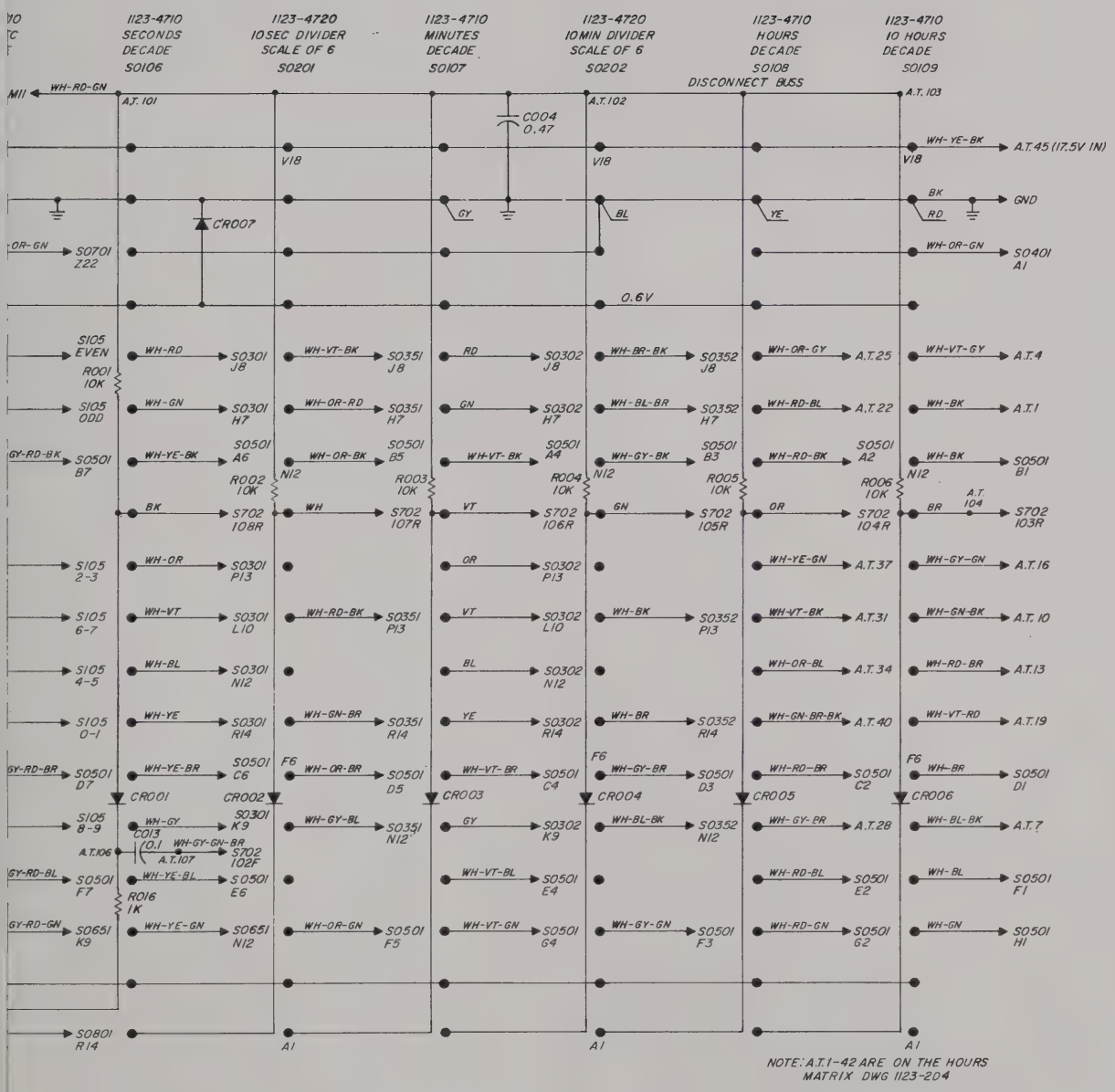
REF NO.	DESCRIPTION	PART NO.
RESISTORS		
R749	Composition 150kΩ ±5% 1/4w	6099-4155
R750	Composition, 150kΩ ±5% 1/4w	6099-4155
R751	Potentiometer, composition, 25kΩ ±20%	6040-0800
R801	Composition, 10kΩ ±5% 1/4w	6099-3105
R802	Composition, 10kΩ ±5% 1/4w	6099-3105
R803	Composition, 100kΩ ±5% 1/4w	6099-4105
R804	Composition, 100kΩ ±5% 1/4w	6099-4105
R805	Composition, 100kΩ ±5% 1/4w	6099-4105
R806	Composition, 10kΩ ±5% 1/4w	6099-3105
R809	Composition, 10kΩ ±5% 1/4w	6099-3105
R813	Composition, 10kΩ ±5% 1/4w	6099-3105
R814	Composition, 100kΩ ±5% 1/4w	6099-4105
R815	Composition, 68kΩ ±5% 1/4w	6099-3685
R816	Composition, 100kΩ ±5% 1/4w	6099-4105
R817	Composition, 10kΩ ±5% 1/4w	6099-3105
R818	Composition, 10kΩ ±5% 1/4w	6099-3105
R819	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R820	Composition, 10kΩ ±5% 1/4w	6099-3105
R821	Composition, 10kΩ ±5% 1/4w	6099-3105
R823	Composition, 100kΩ ±5% 1/4w	6099-4105
R824	Composition, 10kΩ ±5% 1/4w	6099-3105
R825	Composition, 100kΩ ±5% 1/4w	6099-4105
R826	Composition, 100kΩ ±5% 1/4w	6099-4105
R827	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R828	Composition, 47kΩ ±5% 1/4w	6099-3475
R829	Composition, 27kΩ ±5% 1/4w	6099-3275
R830	Composition, 47kΩ ±5% 1/4w	6099-3475
R831	Composition, 100kΩ ±5% 1/4w	6099-4105
R833	Composition, 10kΩ ±5% 1/4w	6099-3105
R834	Composition, 20kΩ ±5% 1/4w	6099-3205
R835	Composition, 200kΩ ±5% 1/4w	6099-4205
R836	Composition, 20kΩ ±5% 1/4w	6099-3205
R837	Composition, 36kΩ ±5% 1/4w	6099-3365
R838	Composition, 1.8kΩ ±5% 1/4w	6099-2185
R839	Composition, 120kΩ ±5% 1/4w	6099-4125
R480	Composition, 10kΩ ±5% 1/4w	6099-3105
R841	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R842	Composition, 2.4kΩ ±5% 1/4w	6099-2245
R843	Composition, 1kΩ ±5% 1/2w	6100-2105
R844	Composition, 510Ω ±5% 1/4w	6099-1515
R901	Composition, 27kΩ ±5% 1/4w	6099-3275
R902	Composition, 3.3kΩ ±5% 1/4w	6099-2335
R903	Composition, 200kΩ ±5% 1/4w	6099-4205
R904	Composition, 200kΩ ±5% 1/4w	6099-4205
R906	Composition, 10kΩ ±5% 1/4w	6099-3105
R907	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R908	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R909	Composition, 100kΩ ±5% 1/4w	6099-4105
R910	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R911	Composition, 100kΩ ±5% 1/4w	6099-4105
R912	Composition, 100kΩ ±5% 1/4w	6099-4105
R913	Composition, 100kΩ ±5% 1/4w	6099-4105
R914	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R915	Composition, 10kΩ ±5% 1/4w	6099-3105
R916	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R917	Composition, 47kΩ ±5% 1/4w	6099-3475
R918	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R919	Composition, 47kΩ ±5% 1/4w	6099-3475
R920	Composition, 47kΩ ±5% 1/4w	6099-3475
R921	Composition, 47kΩ ±5% 1/4w	6099-3475
R922	Composition, 10kΩ ±5% 1/4w	6099-3105
R923	Composition, 27kΩ ±5% 1/4w	6099-3275
R924	Composition, 200Ω ±5% 1/4w	6099-1205
R925	Composition, 2kΩ ±5% 1/4w	6099-2205
R926	Composition, 1kΩ ±5% 1/4w	6100-2105
R927	Composition, 1.3kΩ ±5% 1/4w	6099-2135
R928	Composition, 2kΩ ±5% 1/4w	6099-2205
R929	Composition, 1kΩ ±5% 1/4w	6099-2105
R930	Composition, 2kΩ ±5% 1/4w	6099-2205
R931	Composition, 200Ω ±5% 1/4w	6099-1205
R932	Composition, 51kΩ ±5% 1/4w	6099-3515
R933	Composition, 3kΩ ±5% 1/4w	6099-2305
R934	Composition, 100kΩ ±5% 1/4w	6099-4105
R935	Potentiometer, wire-wound, 10kΩ	0971-4280
R936	Composition, 200kΩ ±5% 1/4w	6099-4205
R937	Composition, 10kΩ ±5% 1/4w	6099-3105
R938	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R939	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R940	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R941	Composition, 100kΩ ±5% 1/4w	6099-4105
R942	Composition, 100kΩ ±5% 1/4w	6099-4105
R943	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R944	Composition, 10kΩ ±5% 1/4w	6099-3105
R945	Composition, 100kΩ ±5% 1/4w	6099-4105
R946	Composition, 15kΩ ±5% 1/4w	6099-3155
R947	Composition, 1kΩ ±5% 1/2w	6100-2105
R948	Composition, 200Ω ±5% 1/4w	6099-1205
R949	Composition, 13kΩ ±5% 1/4w	6099-3135
R950	Composition, 100kΩ ±5% 1/4w	6099-4105
R951	Composition, 100kΩ ±5% 1/4w	6099-4105
R952	Composition, 750Ω P5% 1/2w	6100-1755
R953	Film, 15kΩ ±1% 1/4w	6350-2150
R954	Film, 15kΩ ±1% 1/4w	6350-2150
R955	Film, 15kΩ ±1% 1/4w	6350-2150
R956	Film, 13kΩ ±1% 1/4w	6350-2130
R957	Film, 6.81kΩ ±1% 1/4w	6350-1681
SWITCHES		
S101	Rotary, 10-position, includes thumb-wheel — 10μs TIME DELAY	1123-0410
S102	Rotary, 10-position, includes thumb-wheel — 100μs TIME DELAY	1123-0410
S103	Rotary, 10-position includes thumb-wheel — 1ms TIME DELAY	1123-0410
S104	Rotary, 10-position, includes thumb-wheel — 10ms TIME DELAY	1123-0410
S105	Rotary, 11-position includes thumb-wheel — 100ms TIME DELAY	1123-0411
S401	Rotary, 10-position, includes thumb-wheel — 10's of hrs TIME CYCLE	1123-0410
S402	Rotary, 10-position, includes, thumb-wheel — hrs TIME CYCLE	1123-0410
S501	Slide, spdt — BATTERY POWER	7910-0770
S502	Rotary, 7-position, 2-section, extreme clockwise position is spring return to position 6, uses 5540-3000 gray knob — DIM/READ ON BATTERY	7890-3860
S701	Rotary, 6-position, 2section, uses 5500-1800 gray knob — PROGRAM	7890-3880
S702	Rotary, 8-position, 1-section, extreme clockwise position is spring return to position 7, uses 5500-1800 gray knob — VISUAL REGISTER	7890-3870
S703	Push-button, momentary, normally open contacts — INITIATE	7870-1125
S901	Rotary, 10-position, includes thumb-wheel — 1μs TIME DELAY	1123-0410
SOCKETS		
SO101 thru SO109	18-contact, Methode No. CD618S	4230-2699
SO201	18-contact, Methode No. CD618S	4230-2699
SO301 thru SO304	15-contact, Methode No. CD615S	4230-2715
SO351	15-contact, Methode No. CD615S	4230-2715
SO401	10-contact, Methode No. CD610S	4230-2710
SO501	52-contact, Amphenol 220-698-01 — DIGITAL OUTPUT	4230-5000
SO601	18-contact, Methode No. CD618S	4230-2699
SO651	18-contact, Methode No. CD618S	4230-2699
SO701	24-contact, Methode No. CD624S	4230-2724
SO801	18-contact, Methode No. CD618S	4230-2699
SO901	18-contact, Methode No. CD618S	4230-2699
SO902	10-contact, Methode No. CD610S	4230-2710
TRANSFORMERS		
T501	Power transformer	0485-4021
T601	1114-P2-202	1114-2220

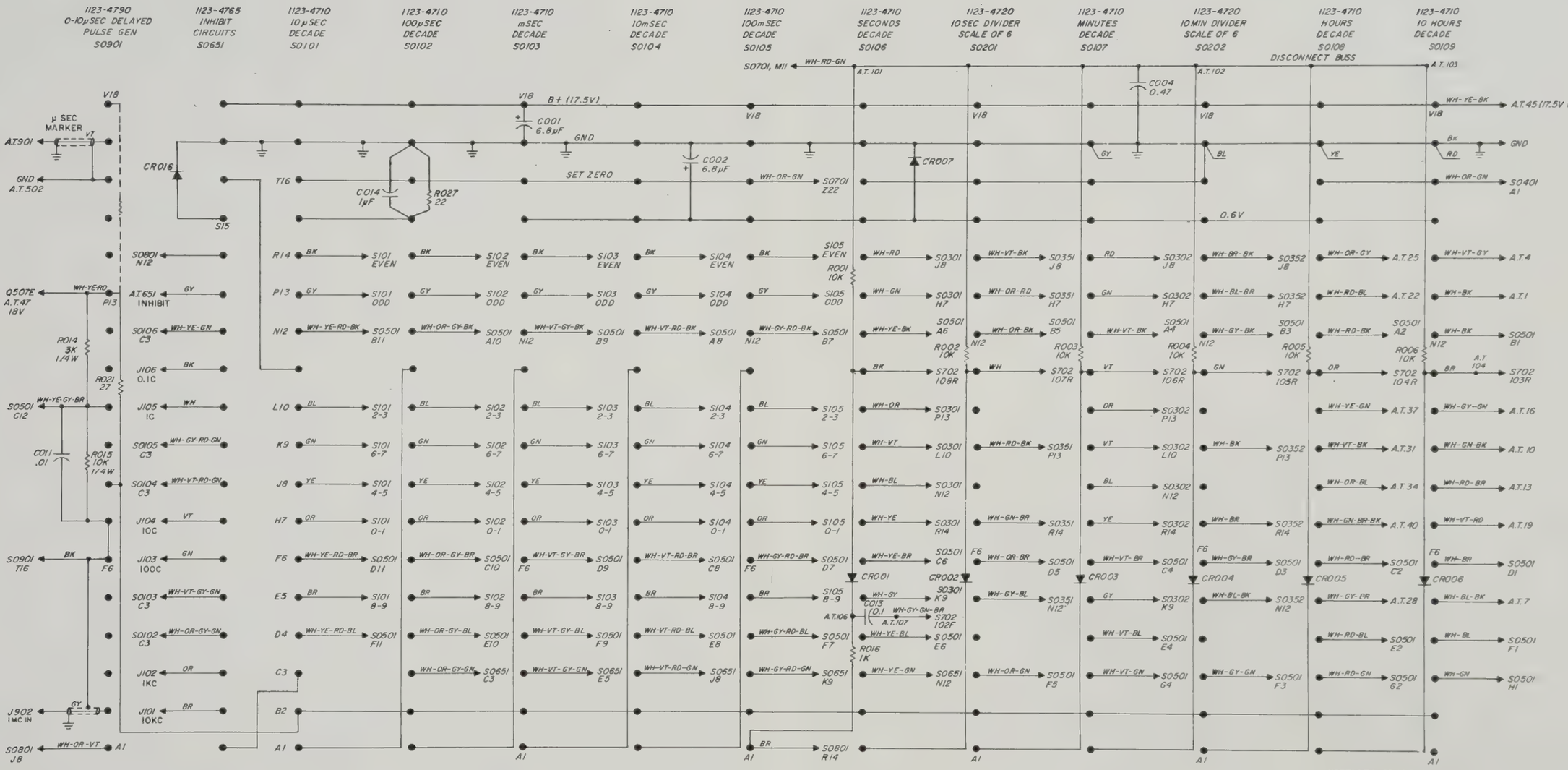

INHIBIT CIRCUIT
S0651
STANDARD FREQUENCIES OUT
1KC J102
10KC J101
100KC J602
IKC BUFFER
10KC BUFFER
BASIC TIMEKEEPING CIRCUITS
INPUT CIRCUIT
S0103
S0102
S0101
1 μs DELAY
(PART OF INHIBIT CIRCUITS)
4.5 μs
4.5 μs
2 μs
G2
G1
INPUT SCHMITT
YELLOW LEAD
100KC INPUT J601
T601
"0" FROM S0701,Z22 (ZERO SET P.G.)
S0601,K9
S0601,L10
S0601,H7
DELAY GENERATOR
LOGIC CIRCUIT
INITIATE S703
+17.5V
S0701,K9
S0701,L10
S0701,X20
S0701 V18
PROGRAM S701
G4
S0801,F6
S0801,A1
G5
S0801,H7
TO S0701,C3 (SYNC FF)
1μs RAMP
IMC INPUT J902
S0901,B2
8ms
START J701
OPERATE
START
STOP
SET
SELF SYNC
START SLAVE
"0" TO SYNC FF AND T16 OF S0101 THRU S0105 (D1 THRU D5)
S0701 Z22
ZERO SET P.G.
45μs
1μs
START P.G
ZERO P.G.
VISUAL REGISTER S702
TO G9
FROM ZERO SET P.G.
+17.5V HOLD
OPERATE
SYNC FF
G3
S0801 J8
S0901 A1
.1μs RAMP
1μSEC
TO S0106,MII(D6)
TO S0201,MII(DS1)
TO S0107,MII(D7)
TO S0202,MII(DS2)
TO S0108,MII(D8)
TO S0108,MII(D9)
SEC
10 SEC
MIN
10 MIN
HOUR
10 HOUR
S0801,K9
8ms PEDESTAL J801
S0901,U17
μs MARKER J901
CARRY DISCONNECT TO D6 THRU D9
S0701,MII
CARRY DISCONNECT FF
FROM G5
S0701,C3
TIME COMPARISON SIGNALS
8ms
0.2 μs
0 TO 990μs SET BY S102,S101
0 TO 10μs SET BY S901,R935

PARTS LIST

REF NO.	DESCRIPTION	PART NO.
RESISTORS		
R749	Composition 150kΩ ±5% 1/4w	6099-4155
R750	Composition, 150kΩ ±5% 1/4w	6099-4155
R751	Potentiometer, composition, 25kΩ ±20%	6040-0800
R801	Composition, 10kΩ ±5% 1/4w	6099-3105
R802	Composition, 10kΩ ±5% 1/4w	6099-3105
R803	Composition, 100kΩ ±5% 1/4w	6099-4105
R804	Composition, 100kΩ ±5% 1/4w	6099-4105
R805	Composition, 100kΩ ±5% 1/4w	6099-4105
R806	Composition, 10kΩ ±5% 1/4w	6099-3105
R809	Composition, 10kΩ ±5% 1/4w	6099-3105
R813	Composition, 10kΩ ±5% 1/4w	6099-3105
R814	Composition, 100kΩ ±5% 1/4w	6099-4105
R815	Composition, 68kΩ ±5% 1/4w	6099-3685
R816	Composition, 100kΩ ±5% 1/4w	6099-4105
R817	Composition, 10kΩ ±5% 1/4w	6099-3105
R818	Composition, 10kΩ ±5% 1/4w	6099-3105
R819	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R820	Composition, 10kΩ ±5% 1/4w	6099-3105
R821	Composition, 10kΩ ±5% 1/4w	6099-3105
R823	Composition, 100kΩ ±5% 1/4w	6099-4105
R824	Composition, 10kΩ ±5% 1/4w	6099-3105
R825	Composition, 100kΩ ±5% 1/4w	6099-4105
R826	Composition, 100kΩ ±5% 1/4w	6099-4105
R827	Composition, 2.2kΩ ±5% 1/4w	6099-2225
R828	Composition, 47kΩ ±5% 1/4w	6099-3475
R829	Composition, 27kΩ ±5% 1/4w	6099-3275
R830	Composition, 47kΩ ±5% 1/4w	6099-3475
R831	Composition, 100kΩ ±5% 1/4w	6099-4105
R833	Composition, 10kΩ ±5% 1/4w	6099-3105
R834	Composition, 20kΩ ±5% 1/4w	6099-3205
R835	Composition, 200kΩ ±5% 1/4w	6099-4205
R836	Composition, 20kΩ ±5% 1/4w	6099-3205
R837	Composition, 36kΩ ±5% 1/4w	6099-3365
R838	Composition, 1.8kΩ ±5% 1/4w	6099-2185
R839	Composition, 120kΩ ±5% 1/4w	6099-4125
R480	Composition, 10kΩ ±5% 1/4w	6099-3105
R841	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R842	Composition, 2.4kΩ ±5% 1/4w	6099-2245
R843	Composition, 1kΩ ±5% 1/2w	6100-2105
R844	Composition, 510Ω ±5% 1/4w	6099-1515
R901	Composition, 27kΩ ±5% 1/4w	6099-3275
R902	Composition, 3.3kΩ ±5% 1/4w	6099-2335
R903	Composition, 200kΩ ±5% 1/4w	6099-4205
R904	Composition, 200kΩ ±5% 1/4w	6099-4205
R906	Composition, 10kΩ ±5% 1/4w	6099-3105
R907	Composition, 5.1 kΩ ±5% 1/4w	6099-2515
R908	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R909	Composition, 100kΩ ±5% 1/4w	6099-4105
R910	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R911	Composition, 100kΩ ±5% 1/4w	6099-4105
R912	Composition, 100kΩ ±5% 1/4w	6099-4105
R913	Composition, 100kΩ ±5% 1/4w	6099-4105
R914	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R915	Composition, 10kΩ ±5% 1/4w	6099-3105
R916	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R917	Composition, 47kΩ ±5% 1/4w	6099-3475
R918	Composition, 4.7kΩ ±5% 1/4w	6099-2475
R919	Composition, 47kΩ ±5% 1/4w	6099-3475
R920	Composition, 47kΩ ±5% 1/4w	6099-3475
R921	Composition, 47kΩ ±5% 1/4w	6099-3475
R922	Composition, 10kΩ ±5% 1/4w	6099-3105
R923	Composition, 27kΩ ±5% 1/4w	6099-3275
R924	Composition, 200Ω ±5% 1/4w	6099-1205
R925	Composition, 2kΩ ±5% 1/4w	6099-2205
R926	Composition, 1kΩ ±5% 1/4w	6100-2105
R927	Composition, 1.3kΩ ±5% 1/4w	6099-2135
R928	Composition, 2kΩ ±5% 1/4w	6099-2205
R929	Composition, 1kΩ ±5% 1/4w	6099-2105
R930	Composition, 2kΩ ±5% 1/4w	6099-2205
R931	Composition, 200Ω ±5% 1/4w	6099-1205
R932	Composition, 51kΩ ±5% 1/4w	6099-3515
R933	Composition, 3kΩ ±5% 1/4w	6099-2305
R934	Composition, 100kΩ ±5% 1/4w	6099-4105
R935	Potentiometer, wire-wound, 10kΩ	0971-4280
R936	Composition, 200kΩ ±5% 1/4w	6099-4205
R937	Composition, 10kΩ ±5% 1/4w	6099-3105
R938	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R939	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R940	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R941	Composition, 100kΩ ±5% 1/4w	6099-4105
R942	Composition, 100kΩ ±5% 1/4w	6099-4105
R943	Composition, 5.1kΩ ±5% 1/4w	6099-2515
R944	Composition, 10kΩ ±5% 1/4w	6099-3105
R945	Composition, 100kΩ ±5% 1/4w	6099-4105
R946	Composition, 15kΩ ±5% 1/4w	6099-3155
R947	Composition, 1kΩ ±5% 1/2w	6100-2105
R948	Composition, 200Ω ±5% 1/4w	6099-1205
R949	Composition, 13kΩ ±5% 1/4w	6099-3135
R950	Composition, 100kΩ ±5% 1/4w	6099-4105
R951	Composition, 100kΩ ±5% 1/4w	6099-4105
R952	Composition, 750Ω P5% 1/2w	6100-1755
R953	Film, 15kΩ ±1% 1/4w	6350-2150
R954	Film, 15kΩ ±1% 1/4w	6350-2150
R955	Film, 15kΩ ±1% 1/4w	6350-2150
R956	Film, 13kΩ ±1% 1/4w	6350-2130
R957	Film, 6.81kΩ ±1% 1/4w	6350-1681
SWITCHES		
S101	Rotary, 10-position, includes thumb-wheel — 10μs TIME DELAY	1123-0410
S102	Rotary, 10-position, includes thumb-wheel — 100μs TIME DELAY	1123-0410
S103	Rotary, 10-position includes thumb-wheel — 1ms TIME DELAY	1123-0410
S104	Rotary, 10-position, includes thumb-wheel — 10ms TIME DELAY	1123-0410
S105	Rotary, 11-position includes thumb-wheel — 100ms TIME DELAY	1123-0411
S401	Rotary, 10-position, includes thumb-wheel — 10's of hrs TIME CYCLE	1123-0410
S402	Rotary, 10-position, includes, thumb-wheel — hrs TIME CYCLE	1123-0410
S501	Slide, spdt — BATTERY POWER	7910-0770
S502	Rotary, 7-position, 2-section, extreme clockwise position is spring return to position 6, uses 5540-3000 gray knob — DIM/READ ON BATTERY	7890-3860
S701	Rotary, 6-position, 2section, uses 5500-1800 gray knob — PROGRAM	7890-3880
S702	Rotary, 8-position, 1-section, extreme clockwise position is spring return to position 7, uses 5500-1800 gray knob — VISUAL REGISTER	7890-3870
S703	Push-button, momentary, normally open contacts — INITIATE	7870-1125
S901	Rotary, 10-position, includes thumb-wheel — 1μs TIME DELAY	1123-0410
SOCKETS		
SO101 thru SO109	18-contact, Methode No. CD618S	4230-2699
SO201	18-contact, Methode No. CD618S	4230-2699
SO301 thru SO304	15-contact, Methode No. CD615S	4230-2715
SO351	15-contact, Methode No. CD615S	4230-2715
SO401	10-contact, Methode No. CD610S	4230-2710
SO501	52-contact, Amphenol 220-698-01 — DIGITAL OUTPUT	4230-5000
SO601	18-contact, Methode No. CD618S	4230-2699
SO651	18-contact, Methode No. CD618S	4230-2699
SO701	24-contact, Methode No. CD624S	4230-2724
SO801	18-contact, Methode No. CD618S	4230-2699
SO901	18-contact, Methode No. CD618S	4230-2699
SO902	10-contact, Methode No. CD610S	4230-2710
TRANSFORMERS		
T501	Power transformer	0485-4021
T601	1114-P2-202	1114-2220


INHIBIT CIRCUIT
INHIBIT J651
S0651
STANDARD FREQUENCIES OUT
100KC J602
BASIC TIMEKEEPING CIRCUITS
INPUT CIRCUIT
FROM S0701, M11 (CARRY DISCONNECT)
FROM S702 HOLD
1 μs DELAY
(PART OF INHIBIT CIRCUITS)
4.5 μs
4.5 μs
2 μs
HOURS RESET (PART OF TIME CYCLE CIRCUIT)
HOURS MATRIX
HOURS MATRIX
FROM EACH DIVIDER:
P13 ODD
R14 EVEN
H7 0, 1
L10 2, 3
J8 4, 5
K9 6, 7
E5 8, 9
"0" FROM S0701, Z22 (ZERO SET P.G)
INPUT SCHMITT
YELLOW LEAD
100KC INPUT J601
T601
10 HOUR 1-6
HOUR 1-5
10 MIN 1-4
MIN 1-3
10 SEC 1-2
SEC 1-1
TIME
LOGIC CIRCUIT
TIME CYCLE CIRCUIT
GATE CIRCUIT
DELAY GENERATOR
TIME DELAY MICROSECONDS
100 ms S105
10 ms S104
1 ms S103
100 μs S102
10 μs S101
1 μs S901
.1 μs R935
HOURS RESET
TENS S401
UNITS S402
TIME CYCLE HOURS
12 μs
5 ms
8 ms
NORMAL
X
TO S0701, C3 (SYNC FF)
1 μs RAMP
.1 μs RAMP
IMC INPUT J902
1 μSEC
1SEC TICK J802
SYNC J803
8ms PEDESTAL J801
μs MARKER J901
TIME COMPARISON SIGNALS
5ms
7μs
8ms
0.2 μs
0 TO 999ms SET BY S105, S104, S103
0 TO 990μs SET BY S102, S101
0 TO 10μs SET BY S901, R935
INITIATE S703
+17.5V
PROGRAM S701
START J701
OPERATE
START
STOP
SET
SELF SYNC
START SLAVE
45μs
1μs
START P.G
ZERO P.G
ZERO SET P.G
"0" TO SYNC FF AND T16 OF S0101 THRU S0105 (D1 THRU D5)
VISUAL REGISTER S702
TO G9
FROM ZERO SET P.G
+17.5V HOLD
SYNC FF
TO S0106, M11 (D6)
TO S0201, M11 (DS1)
TO S0107, M11 (D7)
TO S0202, M11 (DS2)
TO S0108, M11 (D8)
TO S0109, M11 (D9)
SEC
10 SEC
MIN
10 MIN
HOUR
10 HOUR
CARRY DISCONNECT TO D6 THRU D9
CARRY DISCONNECT FF
FROM G5


1123-4710 SECONDS DECADE S0106
1123-4720 10SEC DIVIDER SCALE OF 6 S0201
1123-4710 MINUTES DECADE S0107
1123-4720 10MIN DIVIDER SCALE OF 6 S0202
1123-4710 HOURS DECADE S0108
1123-4710 10 HOURS DECADE S0109
DISCONNECT BUSS
WH-RD-GN
A.T. 101
A.T. 102
A.T. 103
C004 0.47
WH-YE-BK
A.T.45 (17.5V IN)
V18
BK
RD
GND
GY
BL
YE
C R007
WH-OR-GN
S0401 A1
0.6V
S105 EVEN
S105 ODD
R001 10K
WH-RD
WH-VT-BK
RD
WH-BR-BK
WH-OR-GY
WH-VT-GY
A.T.4
WH-GN
WH-OR-RD
GN
WH-BL-BR
WH-RD-BL
A.T.22
WH-BK
A.T.1
GY-RD-BK
S0501 B7
WH-YE-BK
WH-OR-BK
WH-VT-BK
WH-GY-BK
WH-RD-BK
S0501 B1
R002 10K
R003 10K
R004 10K
R005 10K
R006 10K
N12
BK
WH
VT
GN
OR
BR
A.T. 104
S702 108R
S702 107R
S702 106R
S702 105R
S702 104R
S702 103R
S105 2-3
WH-OR
OR
WH-YE-GN
A.T.37
WH-GY-GN
A.T.16
S105 6-7
WH-VT
WH-RD-BK
VT
WH-BK
WH-VT-BK
A.T.31
WH-GN-BK
A.T.10
S105 4-5
WH-BL
BL
WH-OR-BL
A.T.34
WH-RD-BR
A.T.13
S105 0-1
WH-YE
WH-GN-BR
YE
WH-BR
WH-GN-BR-BK
A.T.40
WH-VT-RD
A.T.19
GY-RD-BR
S0501 D7
WH-YE-BR
S0501 C6
F6
WH-OR-BR
WH-VT-BR
WH-GY-BR
WH-RD-BR
WH-BR
S0501 D1
C R001
C R002
C R003
C R004
C R005
C R006
S105 8-9
WH-GY
S0301 K9
WH-GY-BL
GY
WH-BL-BK
WH-GY-PR
A.T.28
WH-BL-BK
A.T.7
C013 0.1
WH-GY-GN-BR
A.T.106
A.T.107
S702 102F
GY-RD-BL
S0501 F7
WH-YE-BL
S0501 E6
WH-VT-BL
S0501 E4
WH-RD-BL
S0501 E2
WH-BL
S0501 F1
R016 1K
GY-RD-GN
S0651 K9
WH-YE-GN
S0651 N12
WH-OR-GN
S0501 F5
WH-VT-GN
S0501 G4
WH-GY-GN
S0501 F3
WH-RD-GN
S0501 G2
WH-GN
S0501 H1
S0801 R14
A1
NOTE: A.T.1-42 ARE ON THE HOURS MATRIX DWG 1123-204

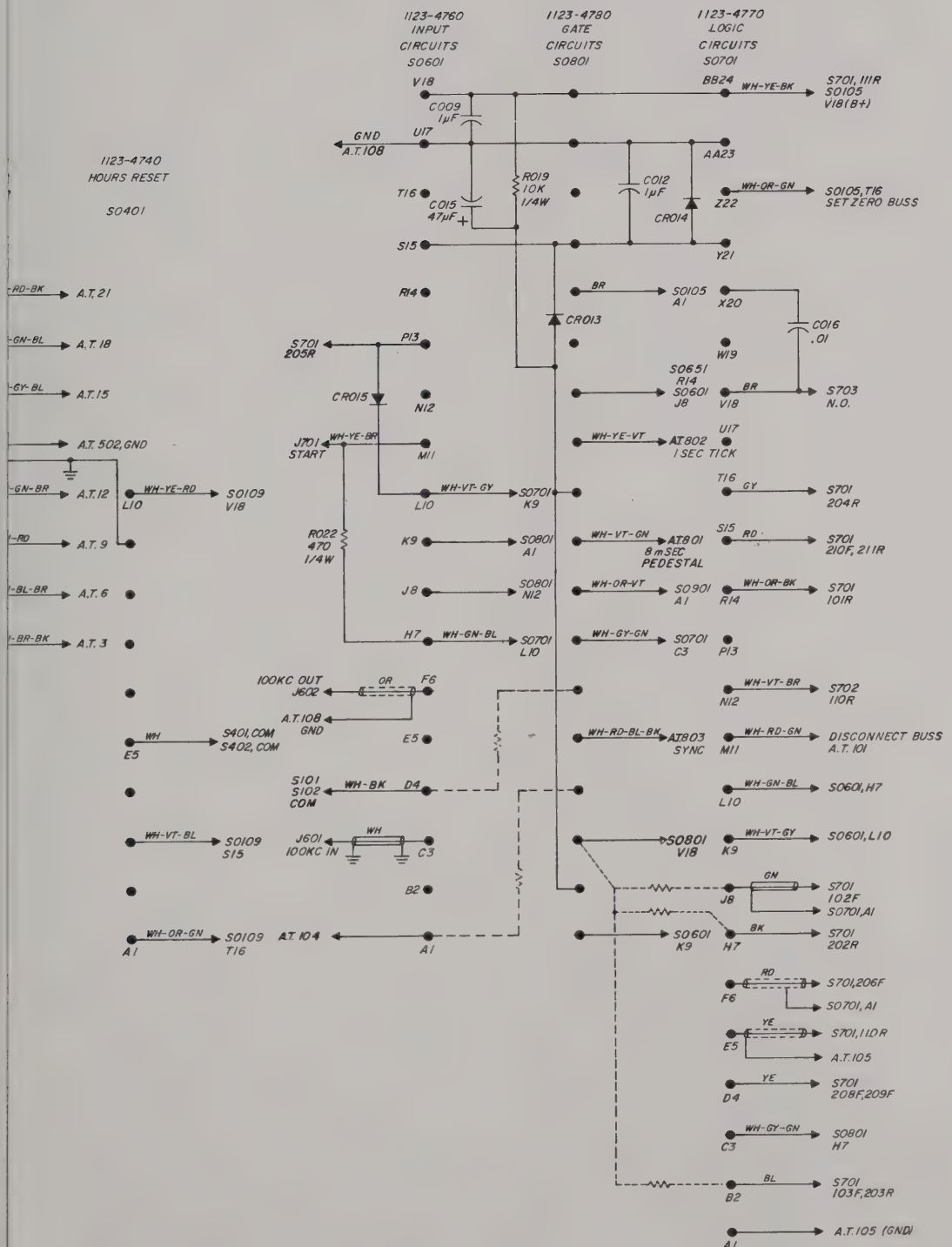


ANCHOR TERMINALS USED: A.T. 101 THRU A.T. 104, 106 & 107

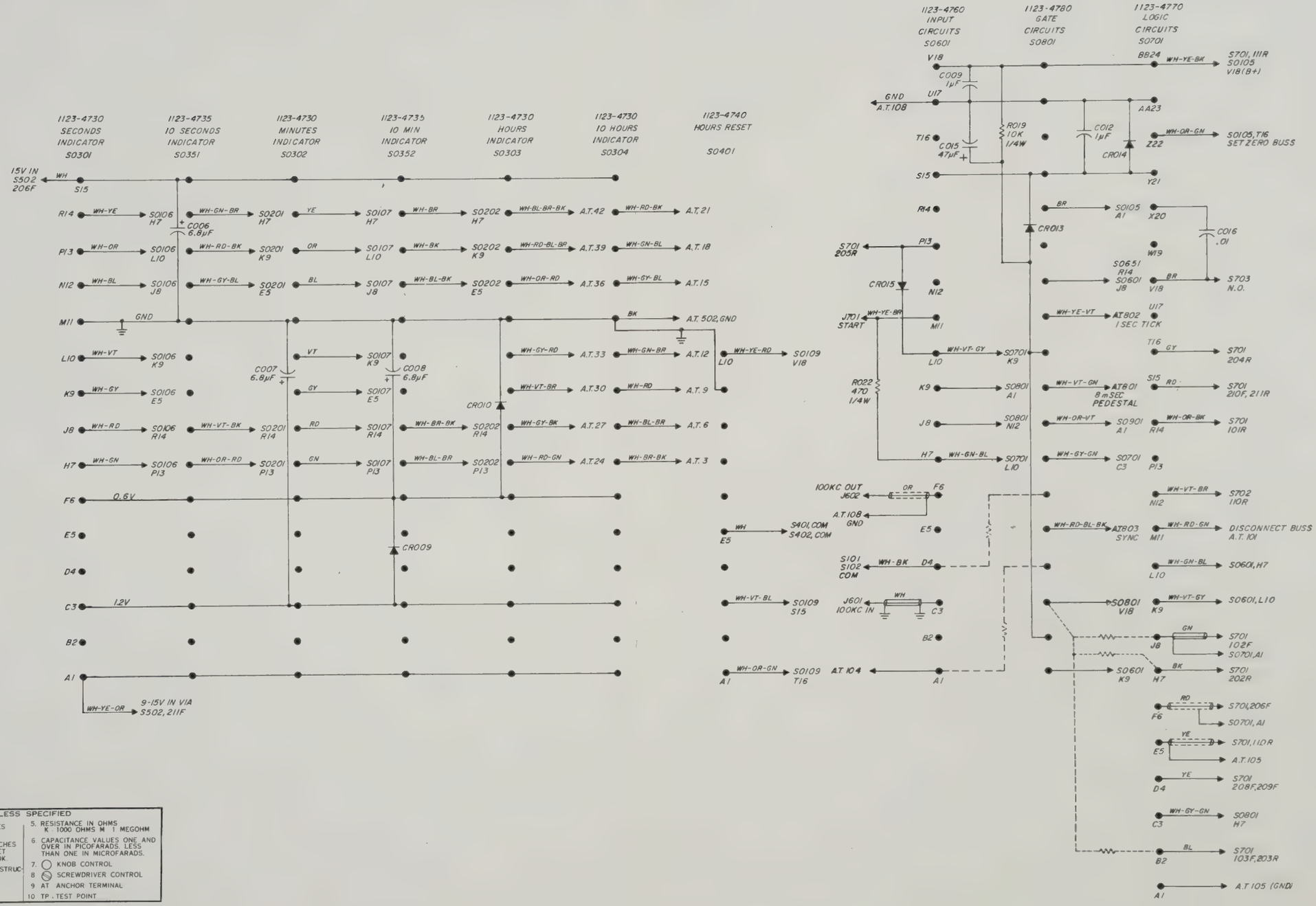
NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

RE ON THE HOURS
G 1123-204)



NOTE:
A.T. 1-42 ARE ON THE HOURS MATRIX (DWG 1123-204)



NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
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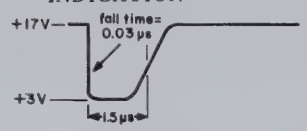
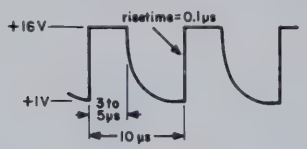
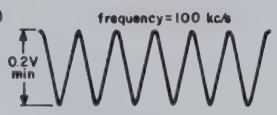
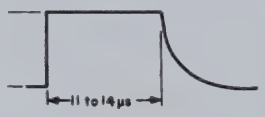
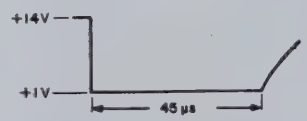
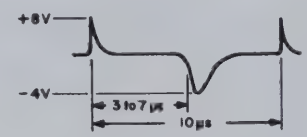
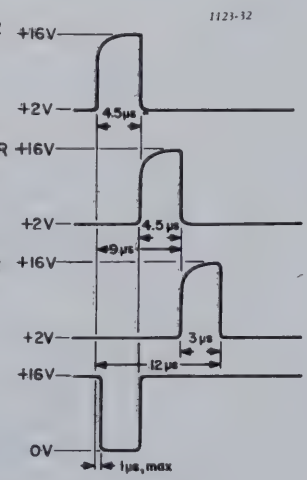
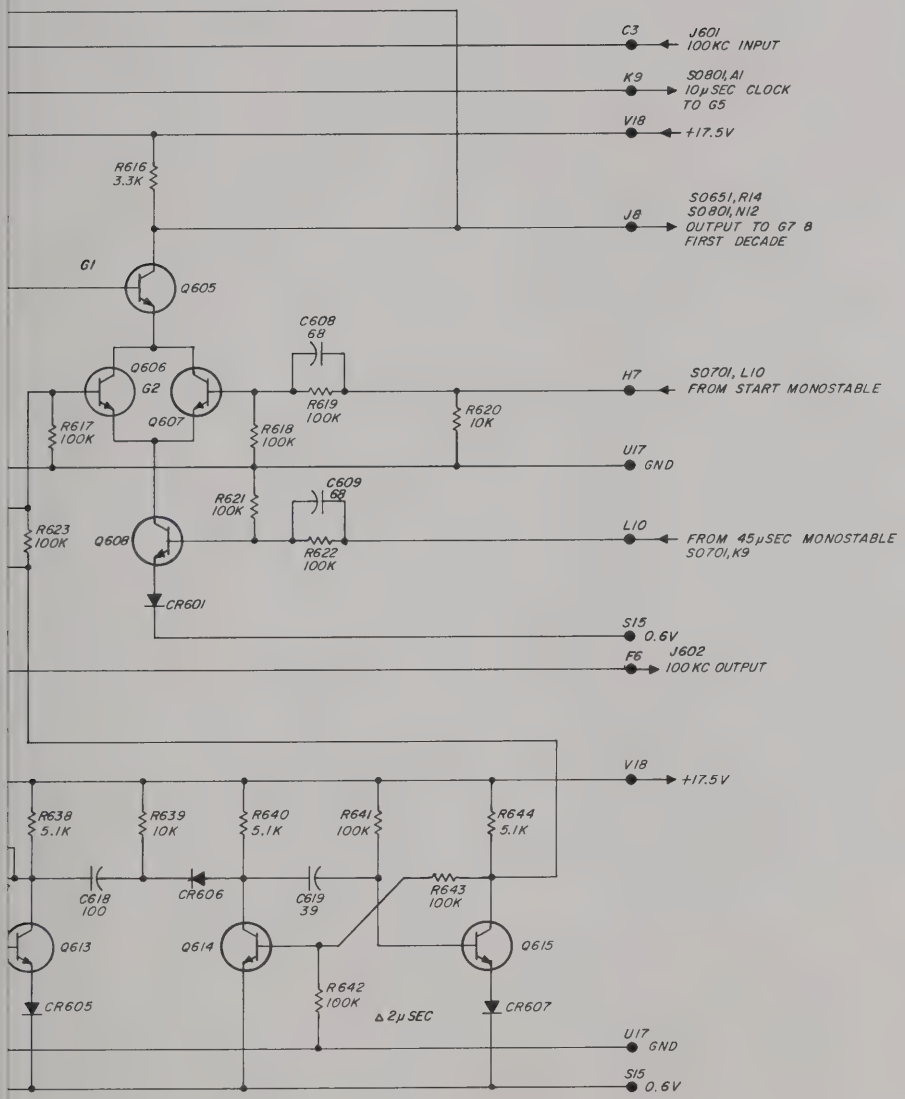
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS. LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP. TEST POINT

INPUT CIRCUIT

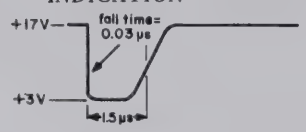
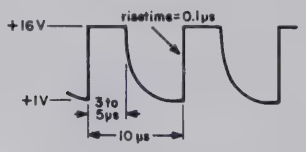
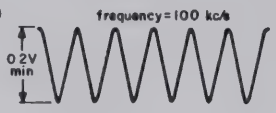
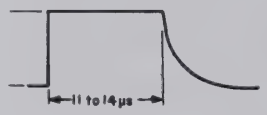
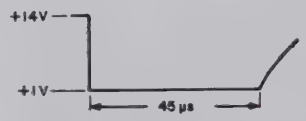
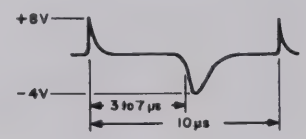
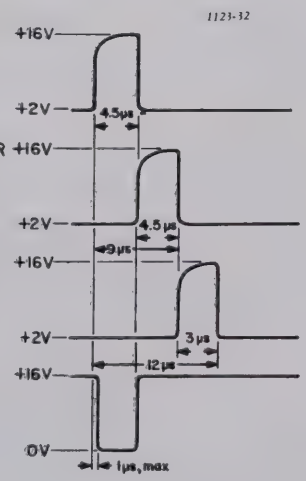
CONDITIONS		*INDICATION*	*NOTES*
100-kc drive applied Clock running.	S0601-J8		S0601-J8 and S0601-K9 (below) check entire input circuit, except Q609.
100-kc drive applied Clock running.	S0601-K9		S0601-K9 and S0601-J8 (above) check entire input circuit, except Q609.
100-kc drive applied.	T601 YELLOW LEAD		Checks T601.
100-kc drive applied. START PROGRAM. INITIATE button pushed.	S0601-H7		Checks start pulse generator in logic circuit.
100-kc drive applied. STOP PROGRAM INITIATE button pushed.	S0601-L10		Checks zero pulse generator in logic circuit
100-kc drive applied. STOP PROGRAM INITIATE button pushed.	Q605 BASE		Checks C607.
100-kc drive applied. S0701-S15 connected to S0601-J8 Scope: external trigger from S0701-S15 OPERATE PROGRAM. INITIATE button pushed.	Q611 COLLECTOR (CASE) Q613 COLLECTOR (CASE) Q615 COLLECTOR (CASE) S0601-F6 OR 100 kc J602		Checks Q610 and Q611 Checks Q612 and Q613 Checks Q614 and Q615 Checks Q609.

100-kc drive disconnected.
S0701-S15 disconnected from S0601-J8

	emitter	*base*	*collector*
Q605	+0.5V	0	+17 V
Q606	+1.2V	+0.8V	+0.5V
Q607	+1.2V	+0.2V	+0.5V
Q608	+1.2V	+1.8V	+1.2V


C3
J601
100KC INPUT
K9
S0801, A1
10μSEC CLOCK
TO G5
V18
+17.5V
R616
3.3K
J8
S0651, R14
S0801, N12
OUTPUT TO G7 8
FIRST DECADE
G1
Q605
C608
68
Q606
G2
Q607
R619
100K
R620
10K
H7
S0701, L10
FROM START MONOSTABLE
R617
100K
R618
100K
U17
GND
C609
68
R621
100K
R623
100K
Q608
L10
FROM 45μSEC MONOSTABLE
S0701, K9
R622
100K
CR601
S15
0.6V
F6
J602
100KC OUTPUT
V18
+17.5V
R638
5.1K
R639
10K
R640
5.1K
R641
100K
R644
5.1K
C618
100
CR606
C619
39
R643
100K
Q613
Q614
Q615
R642
100K
CR605
CR607
△2μSEC
U17
GND
S15
0.6V

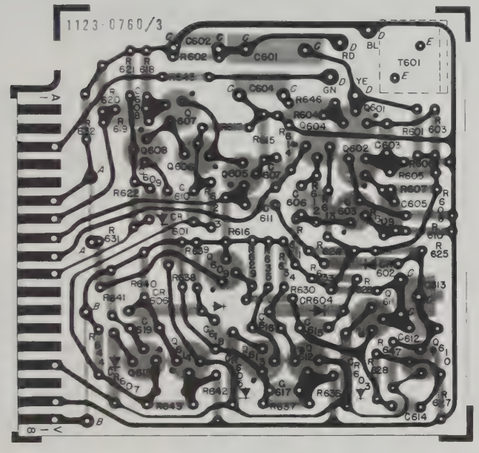
INPUT CIRCUIT

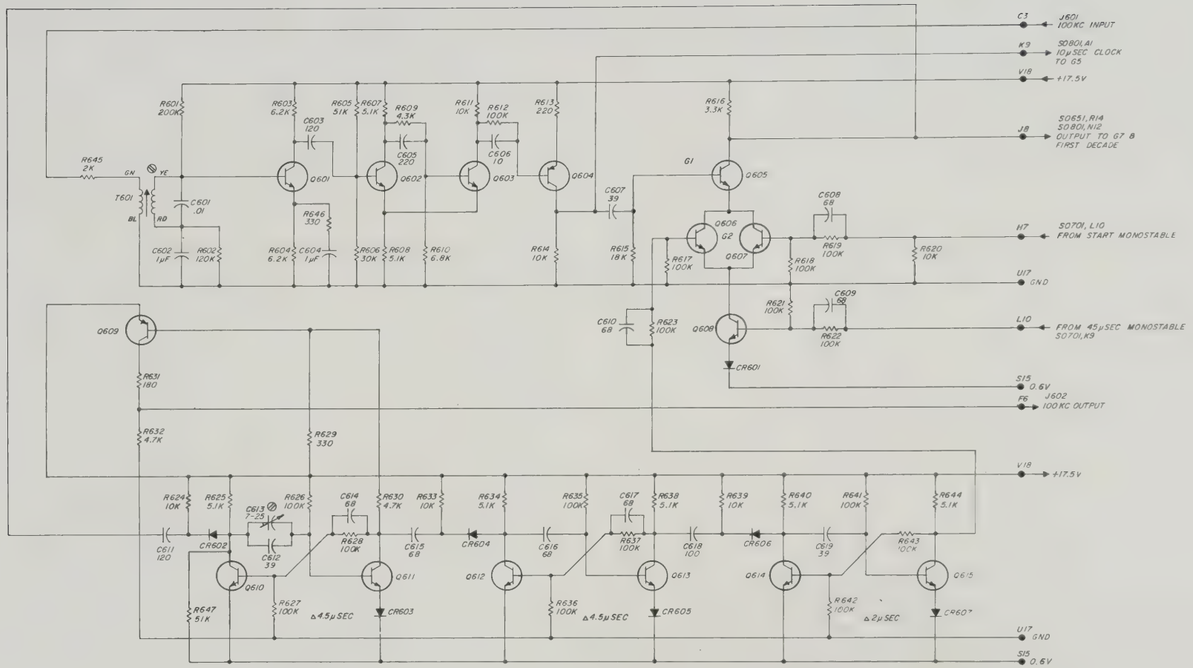
CONDITIONS	*INDICATION*	*NOTES*
100-kc drive applied Clock running.	S0601-J8 	S0601-J8 and S0601-K9 (below) check entire input circuit, except Q609.
100-kc drive applied Clock running.	S0601-K9 	S0601-K9 and S0601-J8 (above) check entire input circuit, except Q609.
100-kc drive applied.	T601 YELLOW LEAD 	Checks T601.
100-kc drive applied. START PROGRAM. INITIATE button pushed.	S0601-H7 	Checks start pulse generator in logic circuit.
100-kc drive applied. STOP PROGRAM INITIATE button pushed.	S0601-L10 	Checks zero pulse generator in logic circuit
100-kc drive applied. STOP PROGRAM INITIATE button pushed.	Q605 BASE 	Checks C607.
100-kc drive applied. S0701-S15 connected to S0601-J8 Scope: external trigger from S0701-S15 OPERATE PROGRAM. INITIATE button pushed.		Checks Q610 and Q611 Checks Q612 and Q613 Checks Q614 and Q615 Checks Q609.

100-kc drive disconnected.
S0701-S15 disconnected from S0601-J8

	emitter	*base*	*collector*
Q605	+0.5V	0	+17 V
Q606	+1.2V	+0.8V	+0.5V
Q607	+1.2V	+0.2V	+0.5V
Q608	+1.2V	+1.8V	+1.2V

INPUT CIRCUIT





BOTTOM VIEW OF Q601, Q605, Q606, Q607, Q608

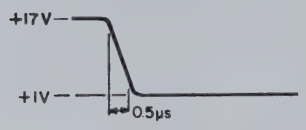
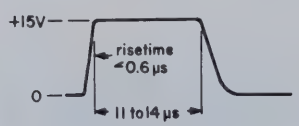
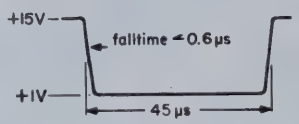
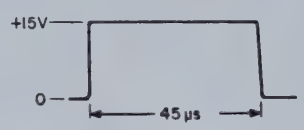
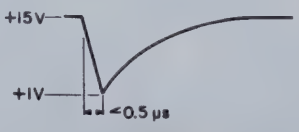
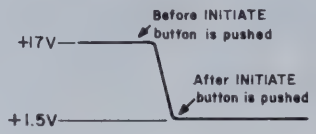
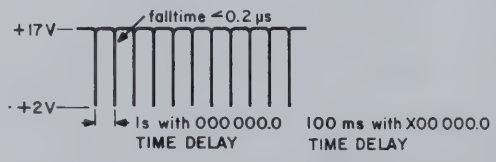
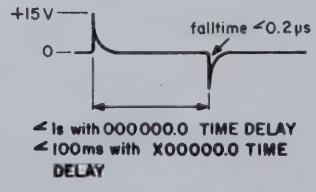
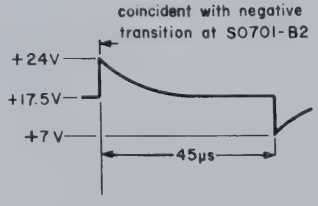
BOTTOM VIEW OF Q602, Q603, Q604, Q610 THRU Q615

BOTTOM VIEW OF Q609

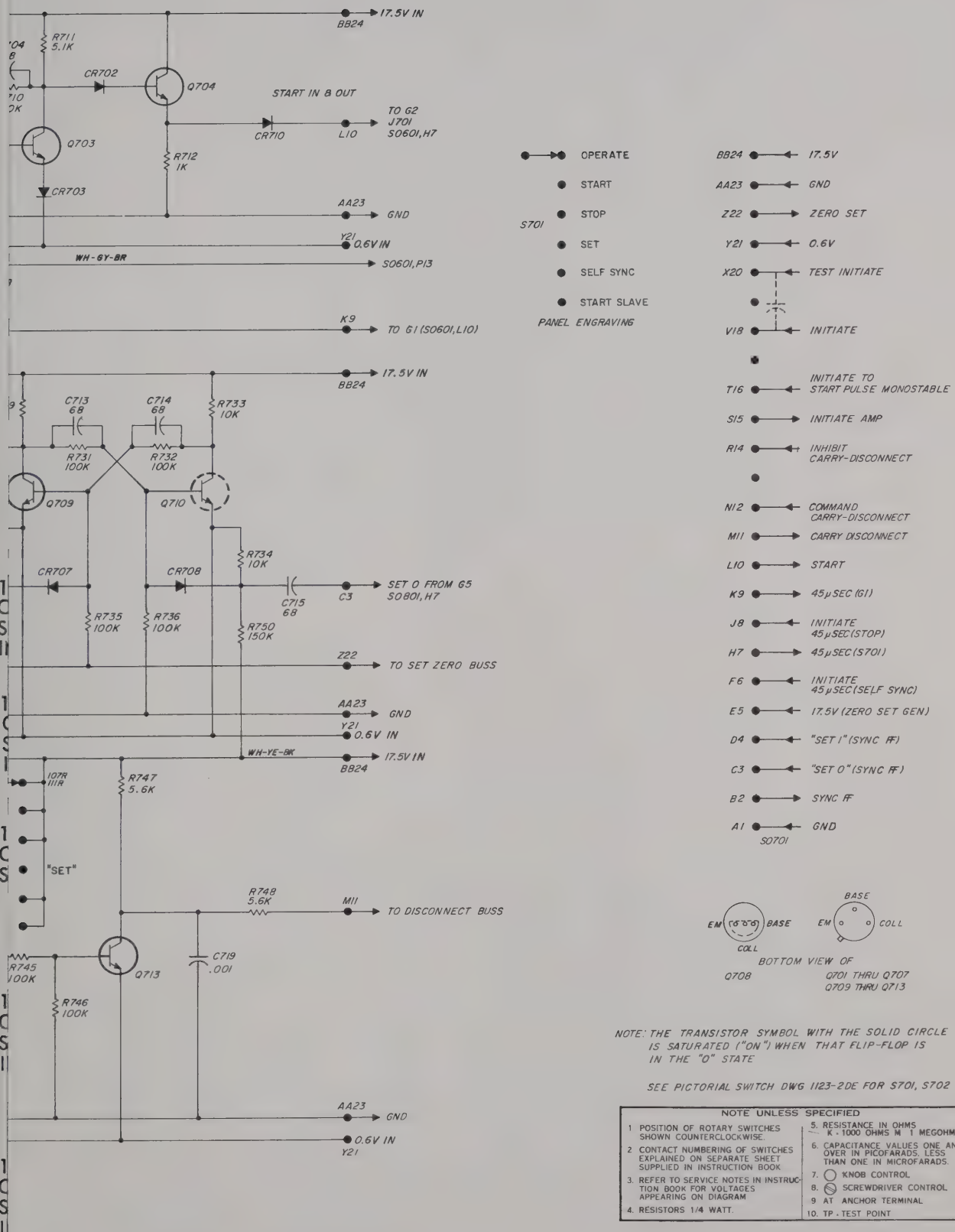
NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN CW/ARCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICROFARADS LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP - TEST POINT

LOGIC CIRCUIT

CONDITIONS		*INDICATIONS*	*NOTES*
100-kc drive disconnected. OPERATE PROGRAM INITIATE button pushed.	S0701-S15		Checks Q707. Waveform should appear each time INITIATE button is pushed
100-kc drive disconnected. START PROGRAM INITIATE button pushed.	S0701-L10		Checks Q702, Q703, and Q704 Waveform should appear each time INITIATE button is pushed.
100-kc drive disconnected. STOP PROGRAM INITIATE button pushed	S0701-K9		Checks Q705, Q706, and Q707. Waveform should appear each time INITIATE button is pushed.
100-kc drive disconnected. STOP PROGRAM INITIATE button pushed.	S0701-Z22		Checks Q708. Waveform should appear each time INITIATE button is pushed.
100-kc drive disconnected. SET PROGRAM VISUAL REGISTER set to OPERATE INITIATE button pushed.	S702-III R		Waveform should appear and second indicator should count, cycle, (and carry) each time INITIATE button is pushed.
100-kc drive disconnected SET PROGRAM VISUAL REGISTER set to SECOND INITIATE button pushed	S0701-M11		Checks Q711, Q712, and Q713. When INITIATE button is pushed, voltage should drop from +17V to +1.5V and should remain +1.5V until either PROGRAM switch setting or VISUAL REGISTER switch setting is changed.
100-kc drive connected Clock running SELF SYNC PROGRAM	S0701-C3		
100-kc drive connected Clock running SELF SYNC PROGRAM INITIATE button pushed.	S0701-B2		Negative transition should appear some time after INITIATE button is pushed. Exact time depends on when INITIATE button was pushed but should be less than 1s with 000 000.0 TIME DELAY and less than 100ms with 000 000.0 TIME DELAY.
100-kc drive connected Clock running SELF SYNC PROGRAM INITIATE button pushed	S0701-H7		Waveform should appear some time after INITIATE button is pushed.

T123-33



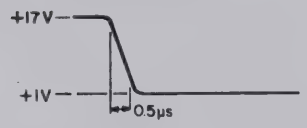
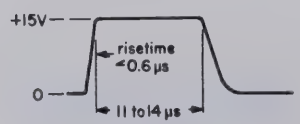
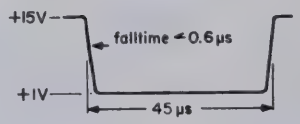
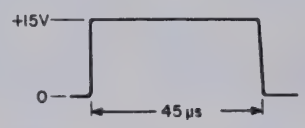
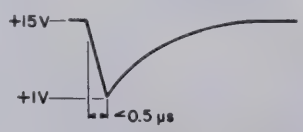
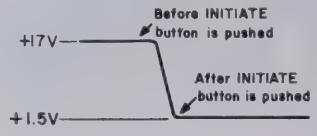
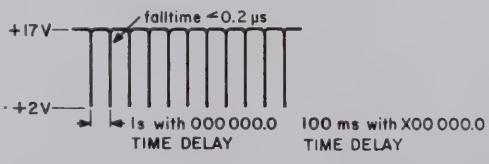
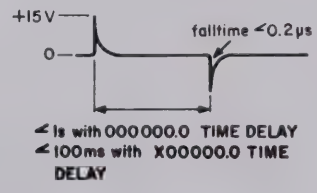
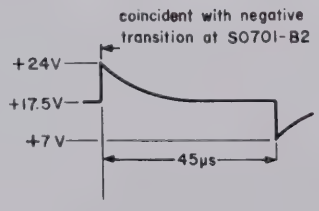
NOTE: THE TRANSISTOR SYMBOL WITH THE SOLID CIRCLE IS SATURATED ("ON") WHEN THAT FLIP-FLOP IS IN THE "0" STATE

SEE PICTORIAL SWITCH DWG 1123-2DE FOR S701, S702

NOTE UNLESS SPECIFIED

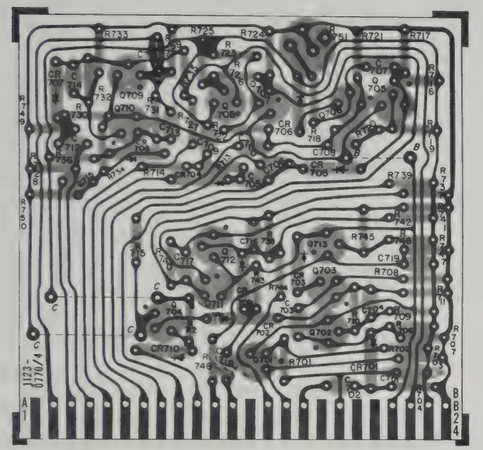
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP - TEST POINT

LOGIC CIRCUIT

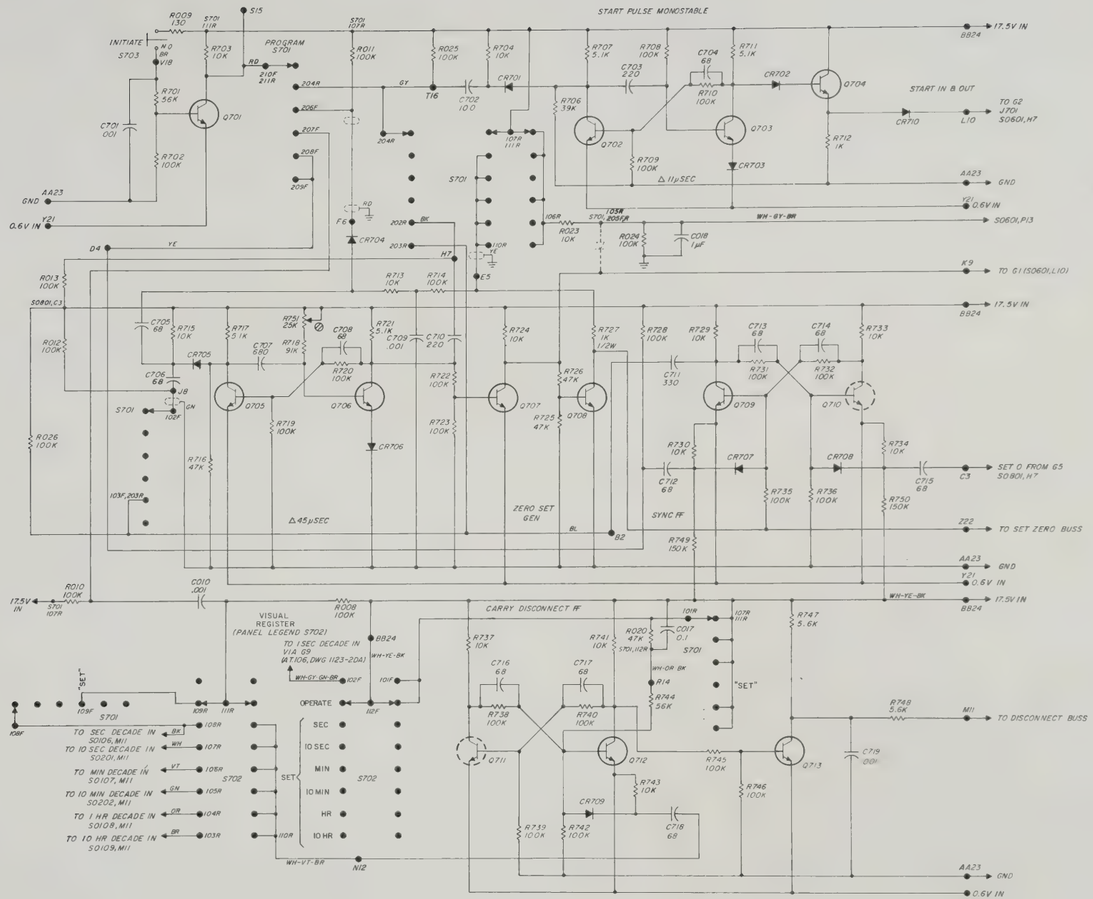
CONDITIONS		*INDICATIONS*	*NOTES*
100-kc drive disconnected. OPERATE PROGRAM INITIATE button pushed.	S0701-S15		Checks Q707. Waveform should appear each time INITIATE button is pushed
100-kc drive disconnected. START PROGRAM INITIATE button pushed.	S0701-L10		Checks Q702, Q703, and Q704 Waveform should appear each time INITIATE button is pushed.
100-kc drive disconnected. STOP PROGRAM INITIATE button pushed	S0701-K9		Checks Q705, Q706, and Q707. Waveform should appear each time INITIATE button is pushed.
100-kc drive disconnected. STOP PROGRAM INITIATE button pushed.	S0701-Z22		Checks Q708. Waveform should appear each time INITIATE button is pushed.
100-kc drive disconnected. SET PROGRAM VISUAL REGISTER set to OPERATE INITIATE button pushed.	S702-III R		Waveform should appear and second indicator should count, cycle, (and carry) each time INITIATE button is pushed.
100-kc drive disconnected SET PROGRAM VISUAL REGISTER set to SECOND INITIATE button pushed	S0701-M11		Checks Q711, Q712, and Q713. When INITIATE button is pushed, voltage should drop from +17V to +1.5V and should remain +1.5V until either PROGRAM switch setting or VISUAL REGISTER switch setting is changed.
100-kc drive connected Clock running SELF SYNC PROGRAM	S0701-C3		
100-kc drive connected Clock running SELF SYNC PROGRAM INITIATE button pushed.	S0701-B2		Negative transition should appear some time after INITIATE button is pushed. Exact time depends on when INITIATE button was pushed but should be less than 1s with 000 000.0 TIME DELAY and less than 100ms with 000 000.0 TIME DELAY.
100-kc drive connected Clock running SELF SYNC PROGRAM INITIATE button pushed	S0701-H7		Waveform should appear some time after INITIATE button is pushed.

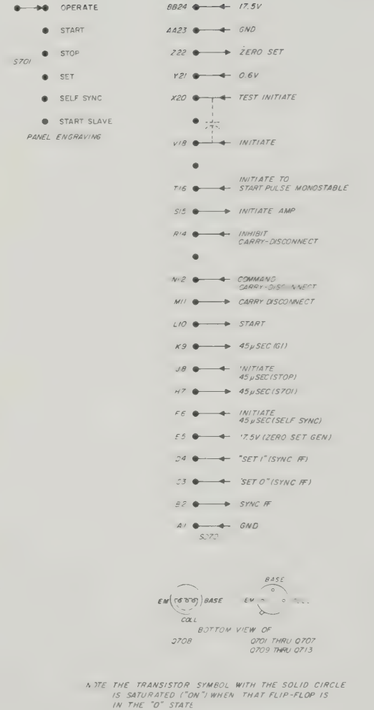
1123-33

LOGIC CIRCUIT



CONDITION	INDICATION	NOTES
100-kc drive connected Clock running SELF SYNC PROGRAM INITIATE button is pushed	S0701-Z22 +14V, 0, 45 μs	Waveform should appear some time after INITIATE button is pushed
100-kc drive connected Clock running SELF SYNC PROGRAM INITIATE button pushed	S0701-L10 +13V, 0, 11 to 14 μs	Waveform should appear some time after INITIATE button is pushed.
100-kc drive connected Clock running START SLAVE PROGRAM	S0701-C3 +15V, 0, falltime — 0.2 μs 1 s with 000000.0 TIME DELAY 100 ms with X000000.0 TIME DELAY 1123-14	
100-kc drive connected Clock running START SLAVE PROGRAM INITIATE button pushed	S0701-B2 +15V, 0, falltime < 0.2 μs < 1 s with 000000.0 TIME DELAY < 100 ms with X000000.0 TIME DELAY	Checks Q709 and Q710. Negative transition should appear sometime after INITIATE button is pushed
100-kc drive connected. Clock running START SLAVE PROGRAM INITIATE button pushed.	S0701-L10 coincident with negative transition at S0701-132 +13V, 0, 11 to 14 μs 1123-15	Checks Q702, Q703, and Q704. Waveform should appear sometime after INITIATE button is pushed



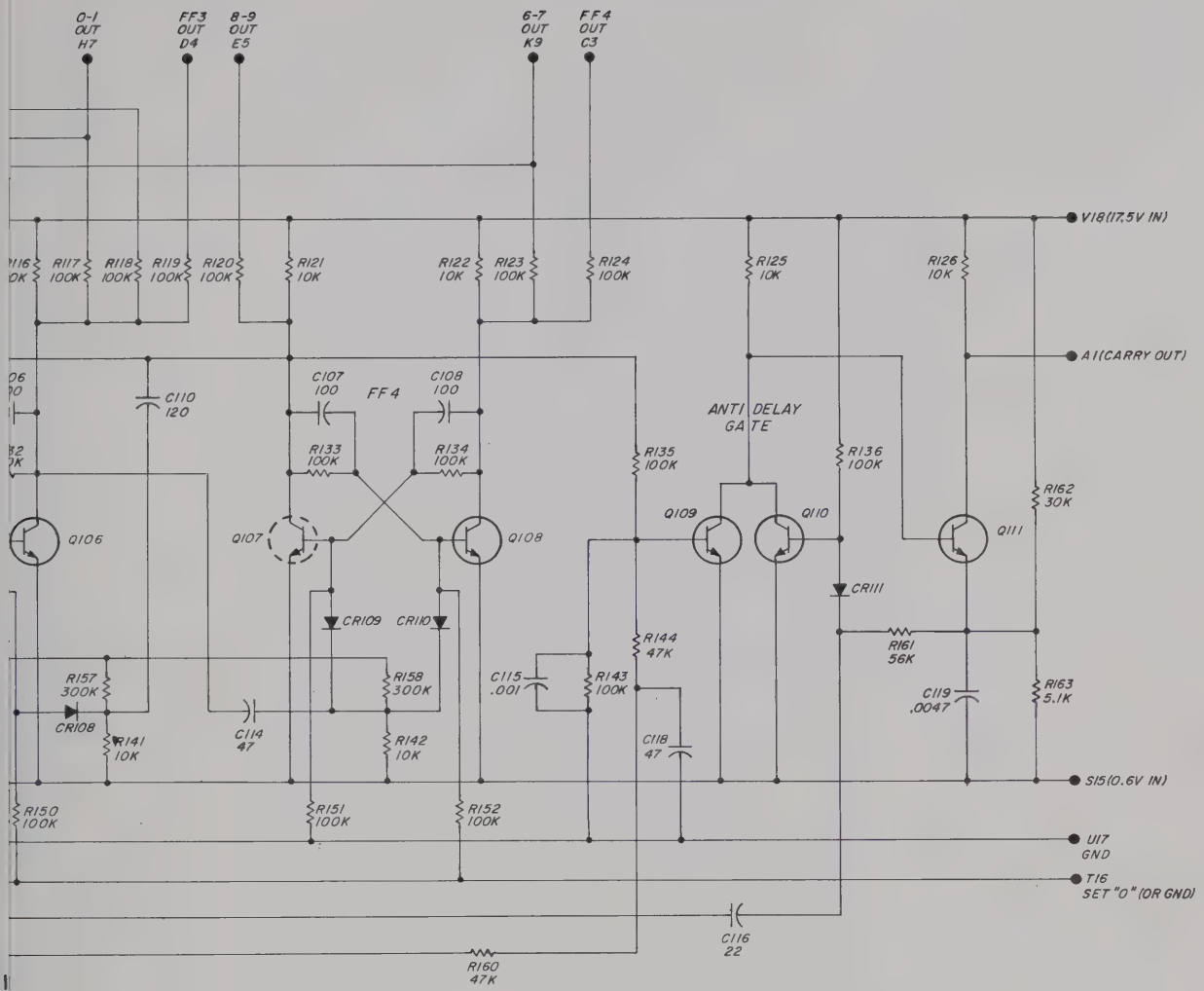


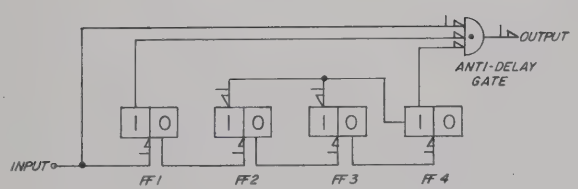
NOTE THE TRANSISTOR SYMBOL WITH THE SOLID CIRCLE IS SATURATED ("ON") WHEN THAT FLIP-FLOP IS IN THE "0" STATE

SEE PICTORIAL SWITCH DWG 1123-2DE FOR S701, S702

NOTE UNLESS SPECIFIED

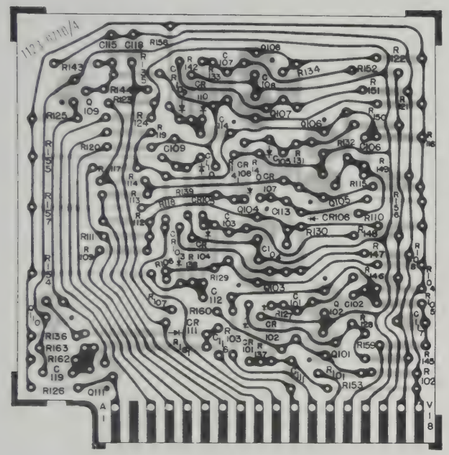
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICROFARADS, LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT



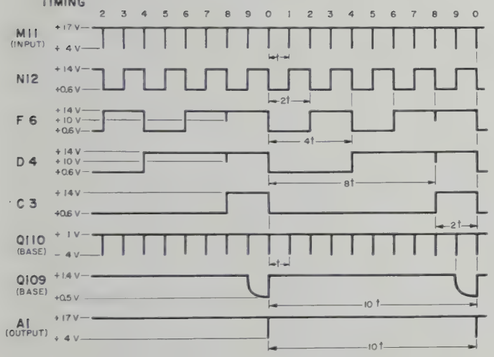


DECIMAL DIGIT	FF1	FF2	FF3	FF4	DIGIT RECOGNITION MATRIX (SHOWN DOTTED)
0	0	0	0	0	0-1
1	1	0	0	0	
2	0	1	0	0	2-3
3	1	1	0	0	
4	0	0	1	0	4-5
5	1	0	1	0	
6	0	1	1	0	6-7
7	1	1	1	0	
8	0	1	1	1	8-9
9	1	1	1	1	

DECADE DIVIDER

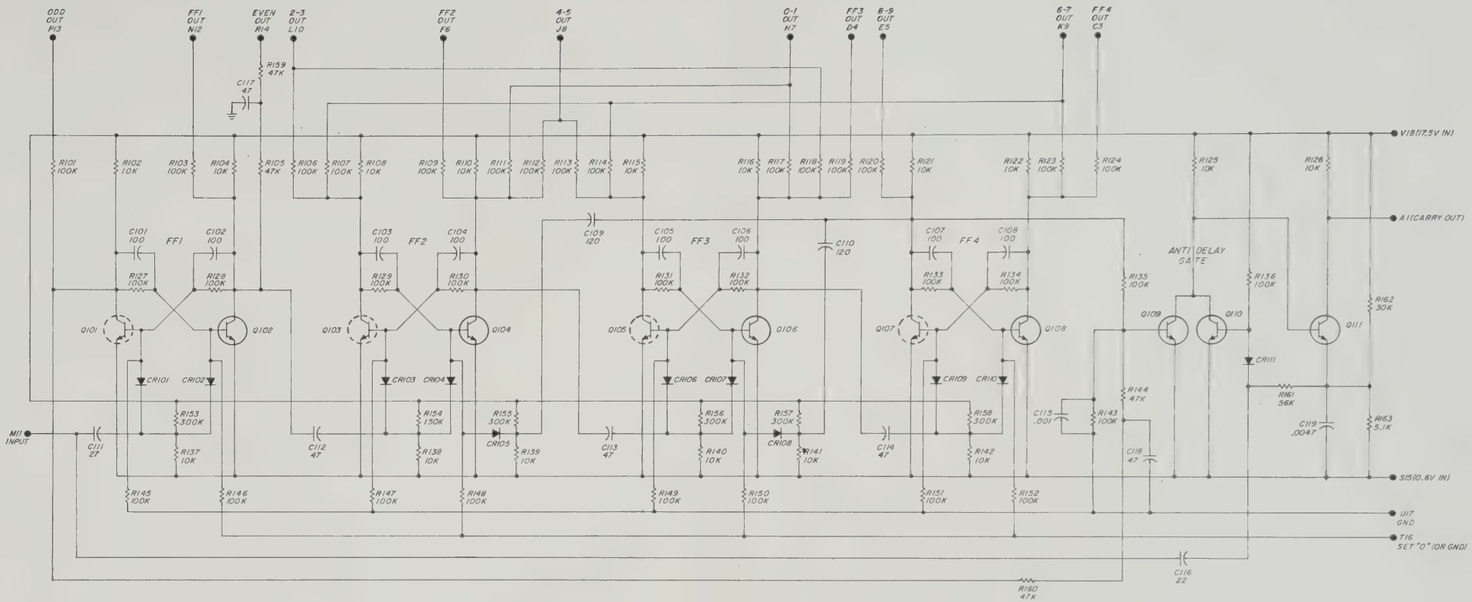


TIMING

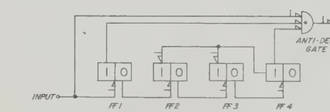


DIVIDER

	D1	D2	D3	D4	D5	D6	D7	D8	D9
t	10	100	1	10	100	1	1	1	10
	μs	μs	ms	ms	ms	s	m	h	h
2t	20	200	2	20	200	2	2	2	20
	μs	μs	ms	ms	ms	s	m	h	h
4t	40	400	4	40	400	4	4	4	40
	μs	μs	ms	ms	ms	s	m	h	h
8t	80	800	8	80	800	8	8	8	80
	μs	μs	ms	ms	ms	s	m	h	h
10t	100	1	10	100	1	10	10	10	100
	μs	ms	ms	ms	s	s	m	h	h



NOTE: THE TRANSISTOR SYMBOL WITH THE SOLID CIRCLE IS SATURATED ("ON") WHEN THAT FLIP-FLOP IS IN THE "0" STATE



DECIMAL DIGIT	FF1	FF2	FF3	FF4	DIGIT RECOGNITION MATRIX (SHOWN DOTTED)
0	0	0	0	0	0
1	1	0	0	0	
2	0	1	0	0	2-3
3	1	1	0	0	
4	0	0	1	0	4-5
5	1	0	1	0	
6	0	1	1	0	6-7
7	1	1	1	0	
8	0	1	1	1	8-9
9	1	1	1	1	

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
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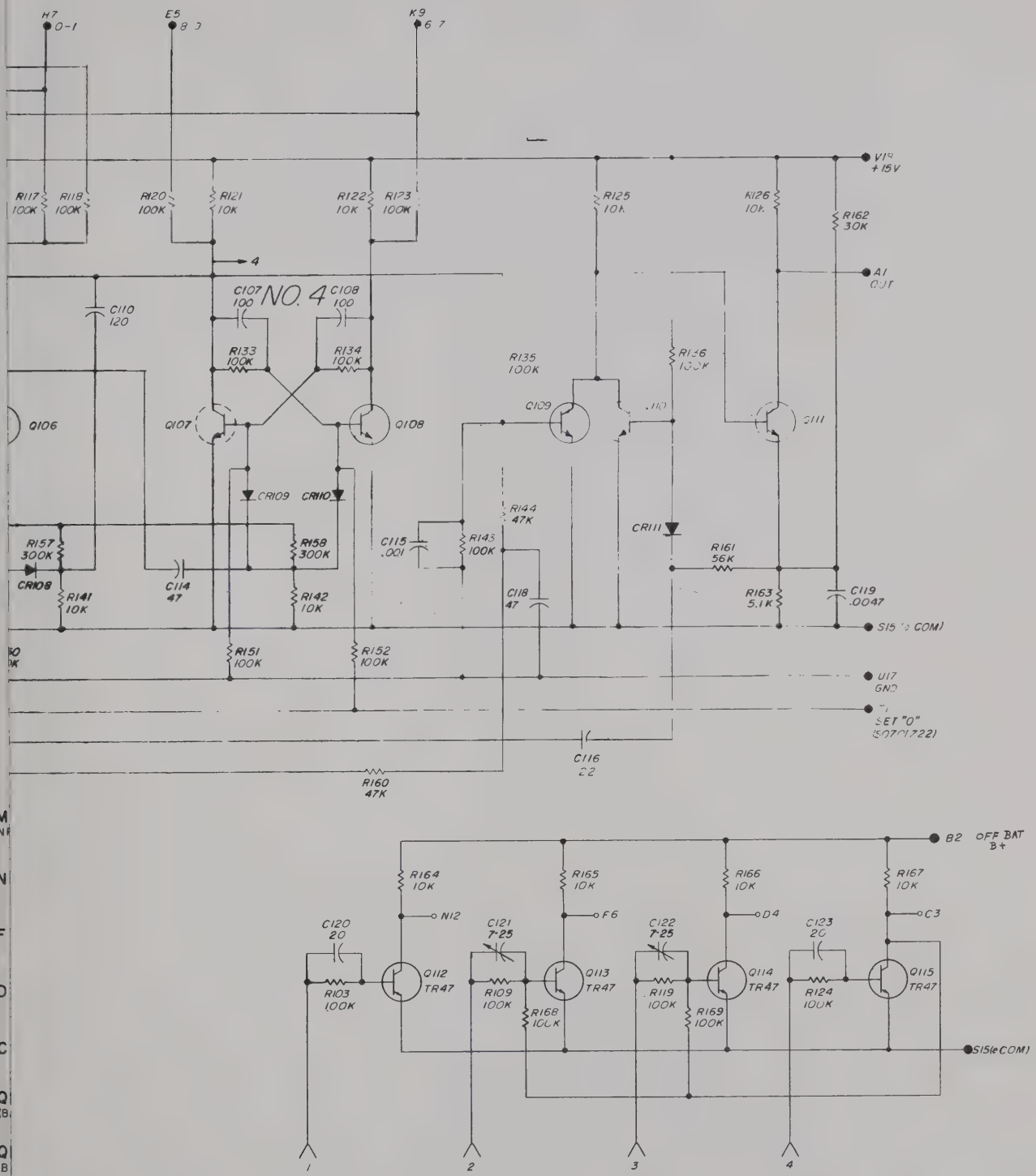
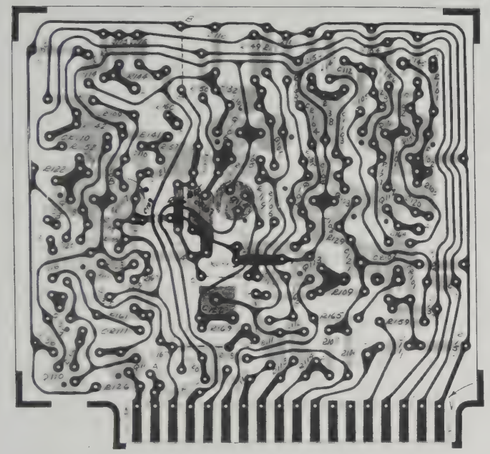
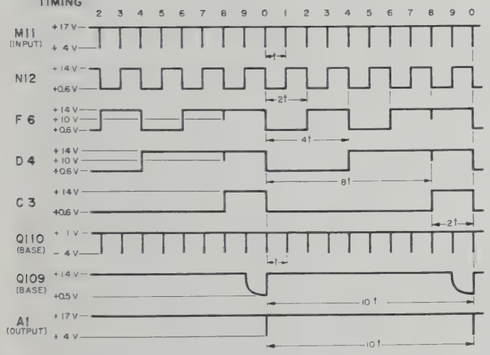
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT


H7
0-1
E5
K9
R117 100K
R118 100K
R120 100K
R121 10K
R122 10K
R123 100K
R125 10K
R126 10K
R162 30K
+15V
A1 OUT
C110 120
C107 100
NO. 4
C108 100
R133 100K
R134 100K
R135 100K
R136 100K
Q106
Q107
Q108
Q109
Q111
CR109
CR110
CR111
R144 47K
R157 300K
R158 300K
R143 100K
C115 .001
R161 56K
CR108
C114 47
R141 10K
R142 10K
C118 47
R163 5.1K
C119 .0047
R151 100K
R152 100K
U17 GND
SET "0"
C116
R160 47K
M (INP
N
F
D
C
Q (B
Q (B
A (OUT
B2 OFF BAT B+
R164 10K
R165 10K
R166 10K
R167 10K
N12
F6
D4
C3
C120 20
C121 7-25
C122 7-25
C123 20
Q112 TR47
Q113 TR47
Q114 TR47
Q115 TR47
R103 100K
R109 100K
R119 100K
R124 100K
R168 100K
R169 100K
S15(e COM)
1
2
3
4

1123-AD DECADE DIVIDER

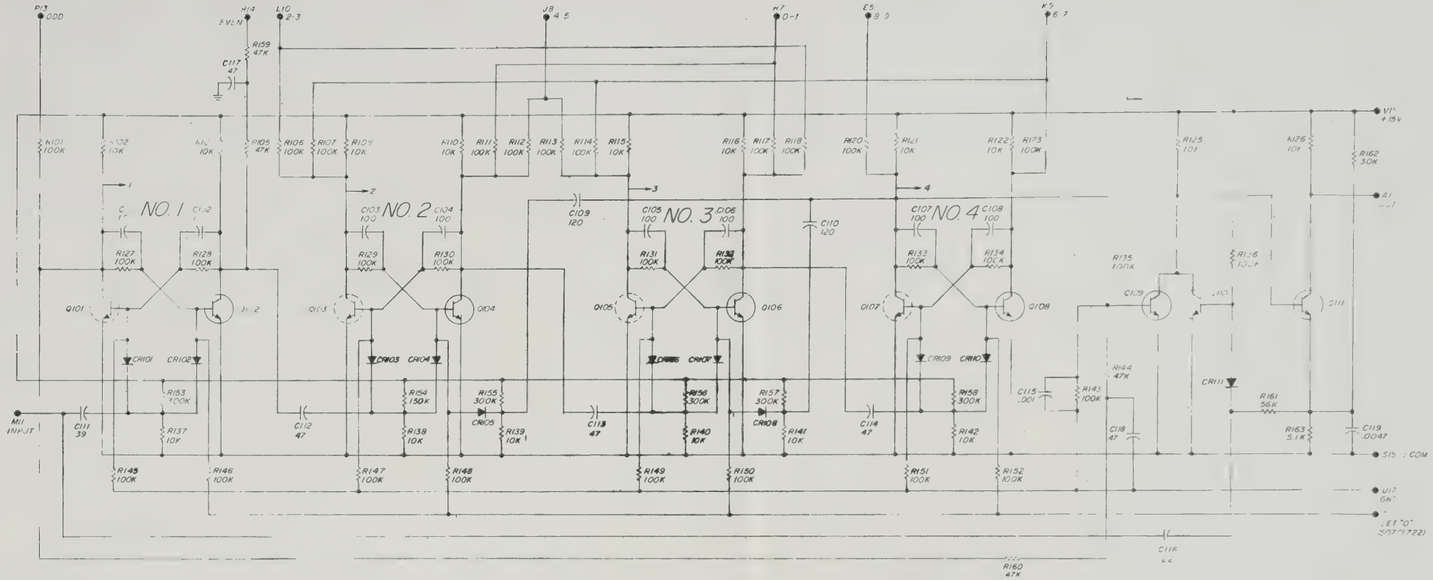


TIMING

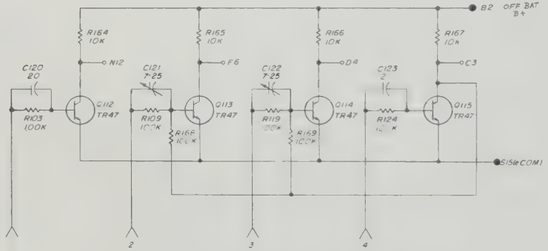


DIVIDER

	D1	D2	D3	D4	D5	D6	D7	D8	D9
t	10	100	1	10	100	1	1	1	10
	μs	μs	ms	ms	ms	s	m	h	h
2t	20	200	2	20	200	2	2	2	20
	μs	μs	ms	ms	ms	s	m	h	h
4t	40	400	4	40	400	4	4	4	40
	μs	μs	ms	ms	ms	s	m	h	h
8t	80	800	8	80	800	8	8	8	80
	μs	μs	ms	ms	ms	s	m	h	h
10t	100	1	10	100	1	10	10	10	100
	μs	ms	ms	ms	s	s	m	h	h

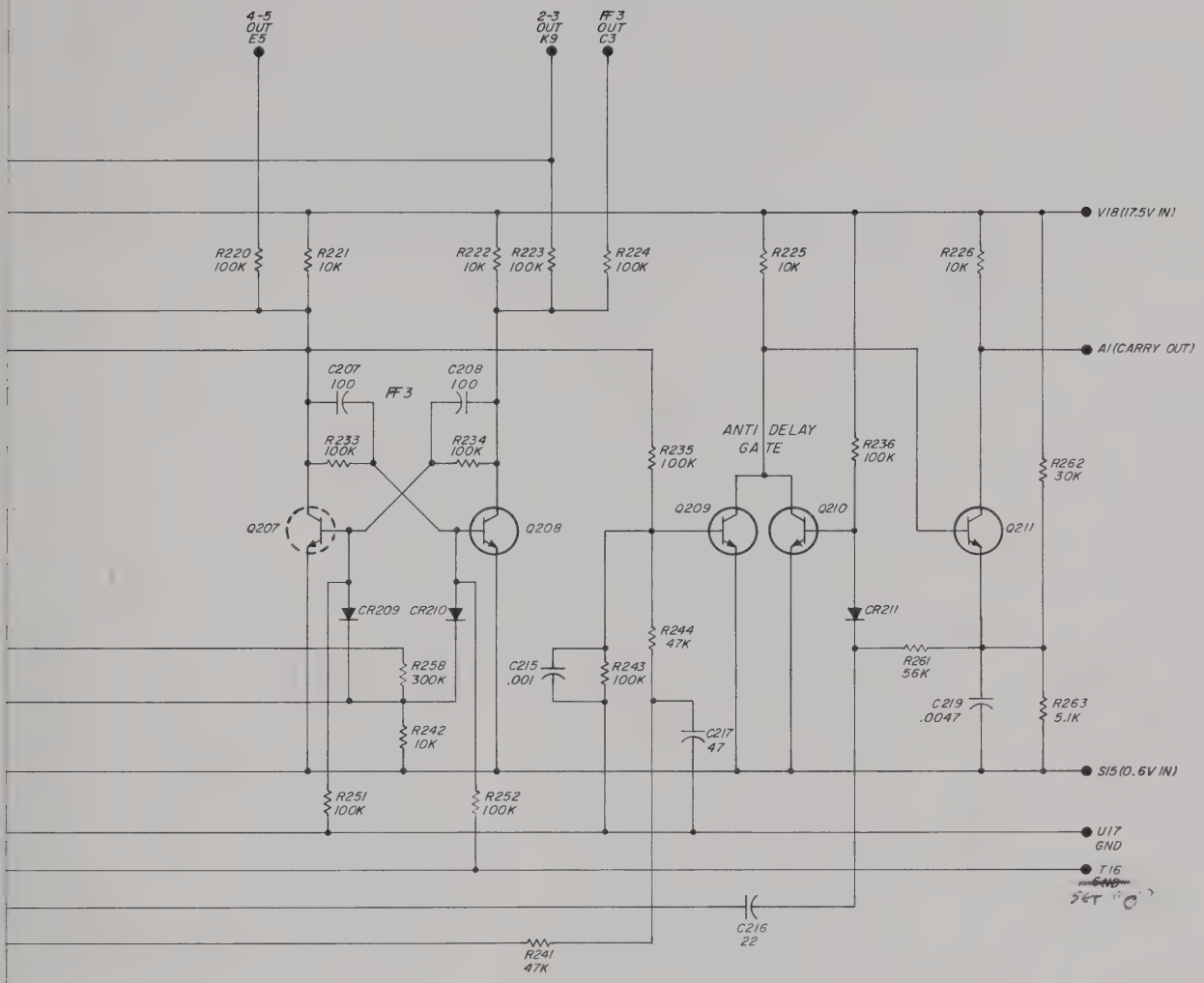


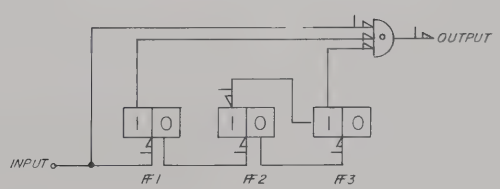
NOTE: THE TRANSISTOR SYMBOL WITH THE SOLID CIRCLE IS SATURATED (ON) WHEN THAT FLIP-FLOP IS IN THE "1" STATE



NOTE UNLESS SPECIFIED

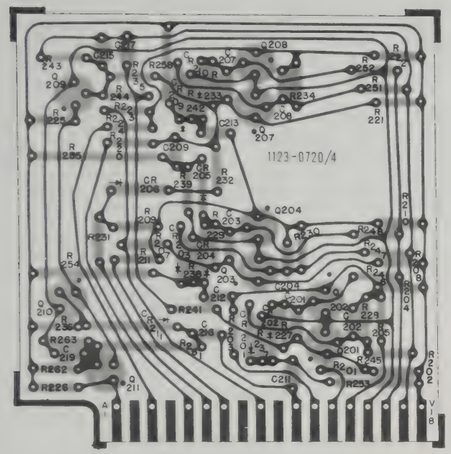
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT = ANCHOR TERMINAL
10. TP = TEST POINT



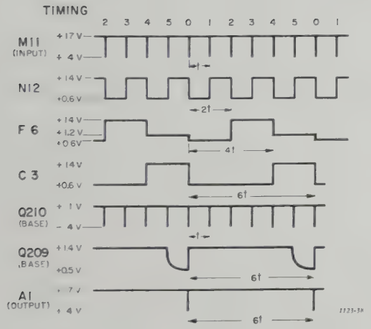


DECIMAL DIGIT	FF1	FF2	FF3	DIGIT RECOGNITION MATRIX (SHOWN DOTTED)
0	0	0	0	0-1
1	1	0	0	
2	0	1	0	2-3
3	1	1	0	
4	0	1	1	4-5
5	1	1	1	

SCALE OF SIX DIVIDER

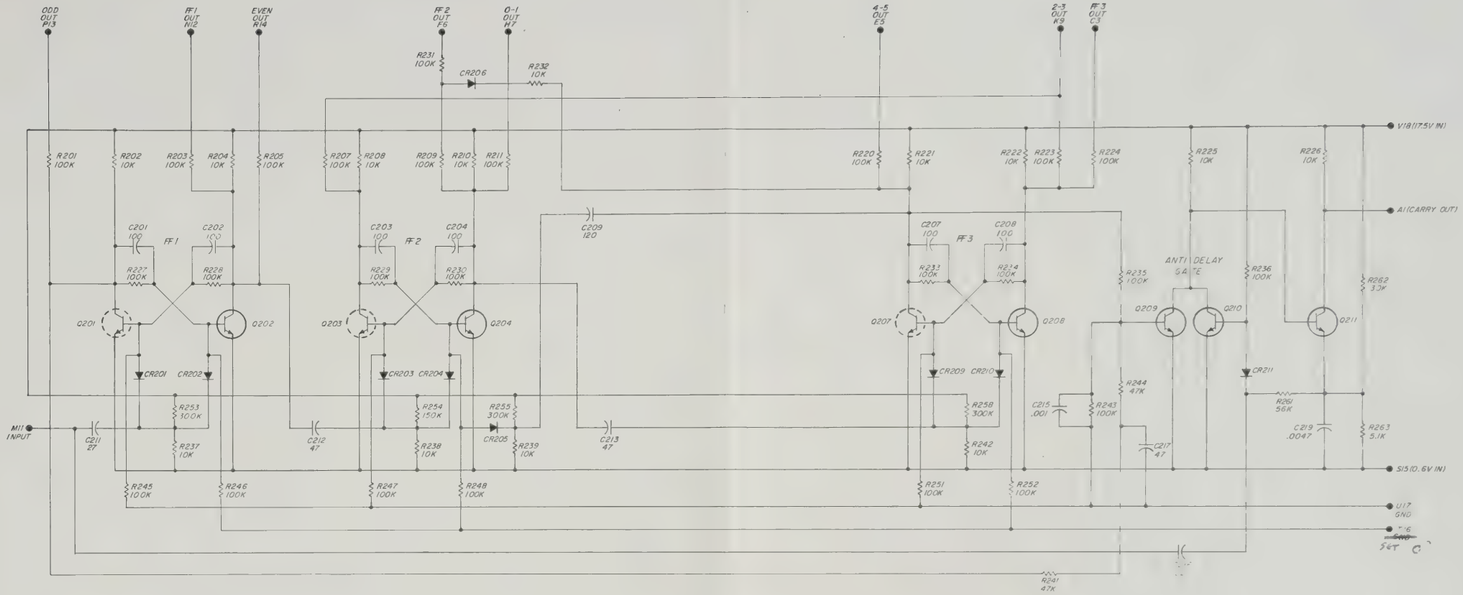


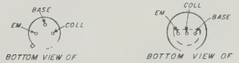
TIMING



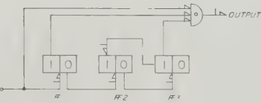
DIVIDER

	DS1	*DS2*
t	10	10
	s	m
2t	20	20
	s	m
4t	40	40
	s	m
6t	60	60
	s	m





NOTE: THE TRANSISTOR SYMBOL WITH THE SOLID CIRCLE IS SATURATED ("ON") WHEN THAT FLIP-FLOP IS IN THE "0" STATE



DECIMAL DIGIT	FF1	FF2	FF3	RECOGNITION MATRIX (SHOWN DOTTED)
0	0	0	0	
1	1	0	0	0-1
2	0	1	0	
3	1	1	0	2-3
4	0	0	1	
5	1	0	1	4-5

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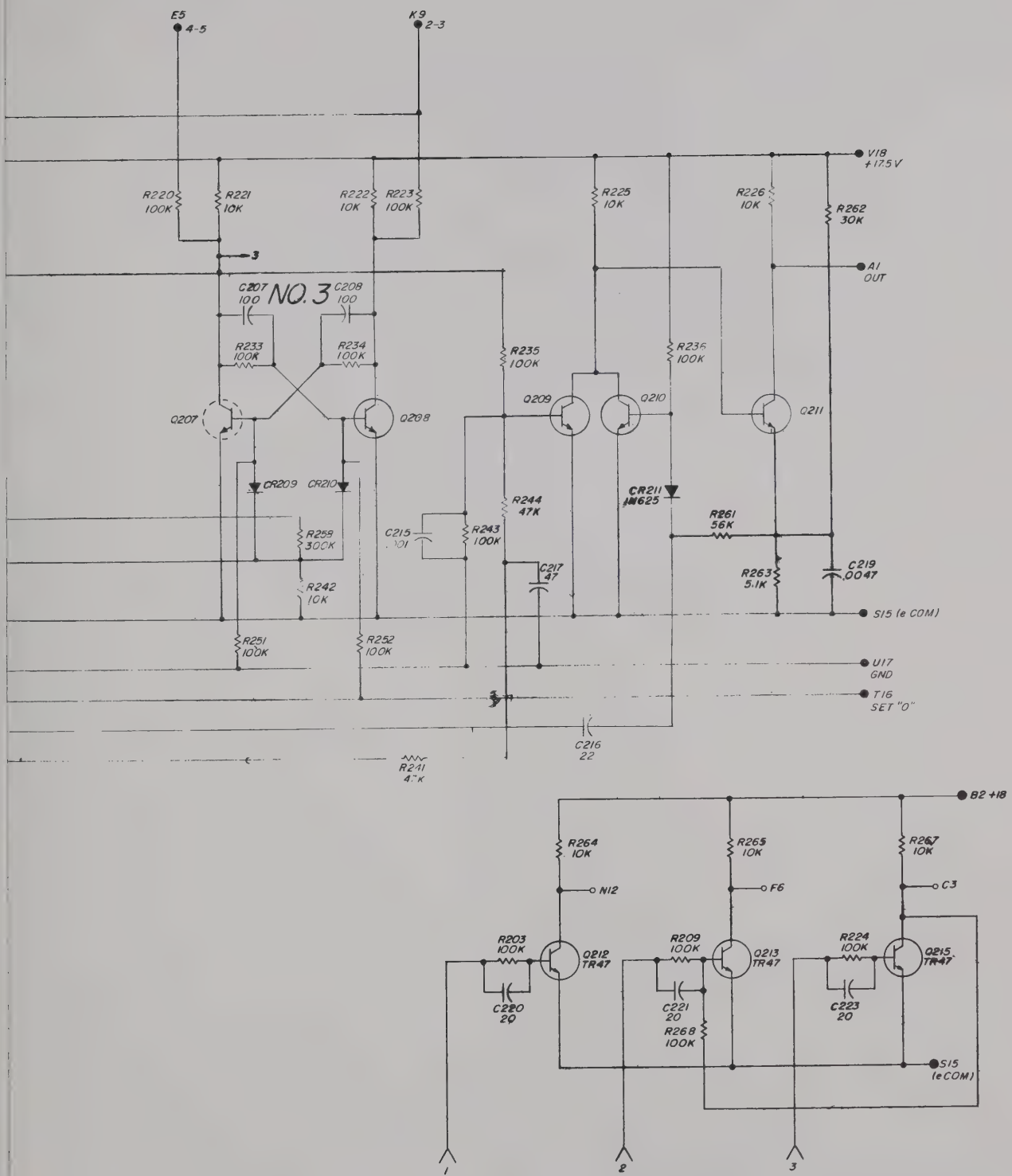
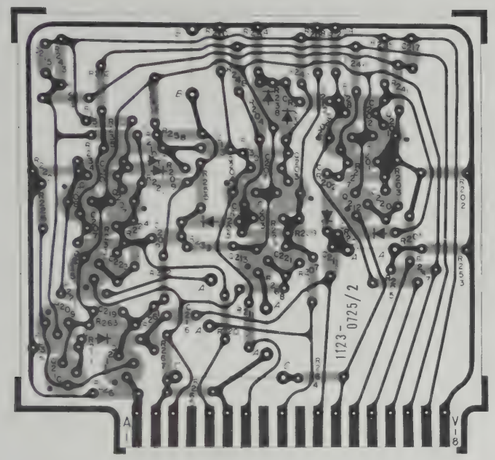
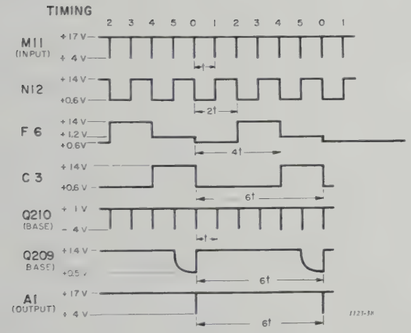
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT


E5
4-5
K9
2-3
V18
+17.5V
R220
100K
R221
10K
R222
10K
R223
100K
R225
10K
R226
10K
R262
30K
A1
OUT
3
C207
100
NO. 3
C208
100
R233
100K
R234
100K
R235
100K
R236
100K
Q207
Q208
Q209
Q210
Q211
CR209
CR210
CR211
1N625
R244
47K
R261
56K
C215
.001
R243
100K
C217
47
R263
5.1K
C219
.0047
R259
300K
R242
10K
S15 (e COM)
R251
100K
R252
100K
U17
GND
T16
SET "0"
C216
22
R241
4.7K
B2 +18
R264
10K
R265
10K
R267
10K
N12
F6
C3
R203
100K
Q212
TR47
R209
100K
Q213
TR47
R224
100K
Q215
TR47
C220
20
C221
20
C223
20
R268
100K
S15
(e COM)
1
2
3

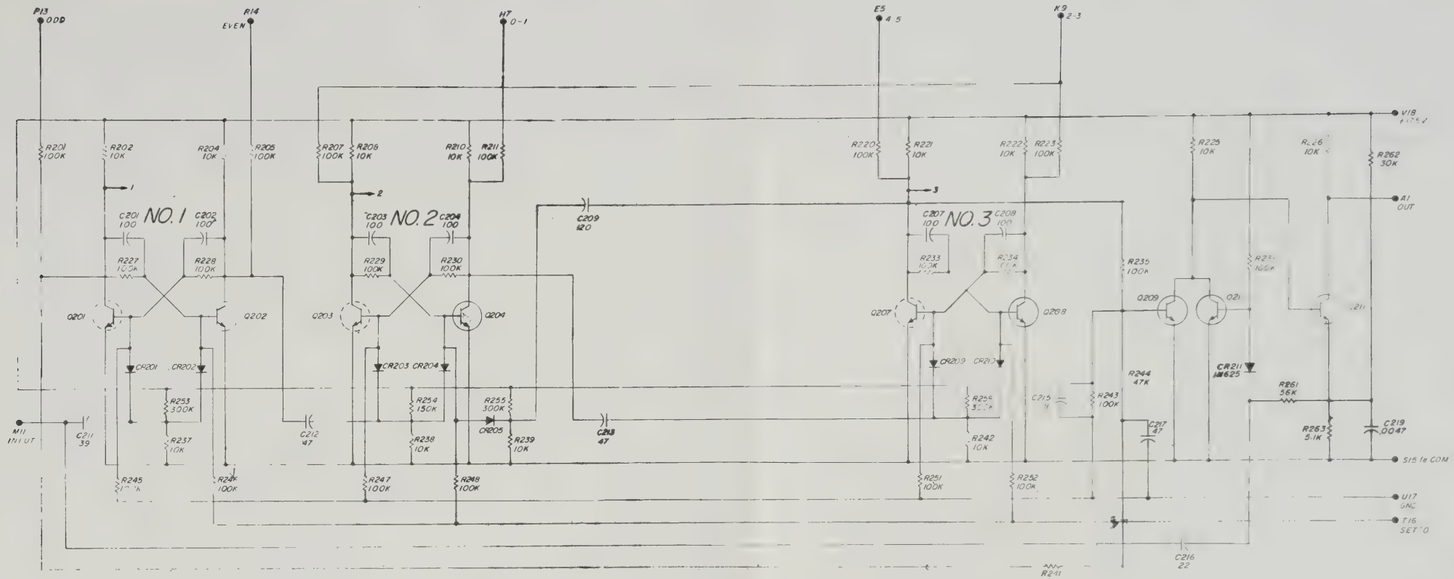
1123-AD SCALE OF SIX DIVIDER



TIMING



DIVIDER	DS1	DS2
t	10 s	10 m
2t	20 s	20 m
4t	40 s	40 m
6t	60 s	60 m



BOTTOM VIEW OF ... Q21...

BOTTOM VIEW OF Q201, Q202, Q203, Q204 Q207, Q208, Q209

NOTE: THE TRANSISTOR SYMBOL WITH THE SOLID CIRCLE IS SATURATED ("ON") WHEN THAT FLIP FLOP IS IN THE "0" STATE

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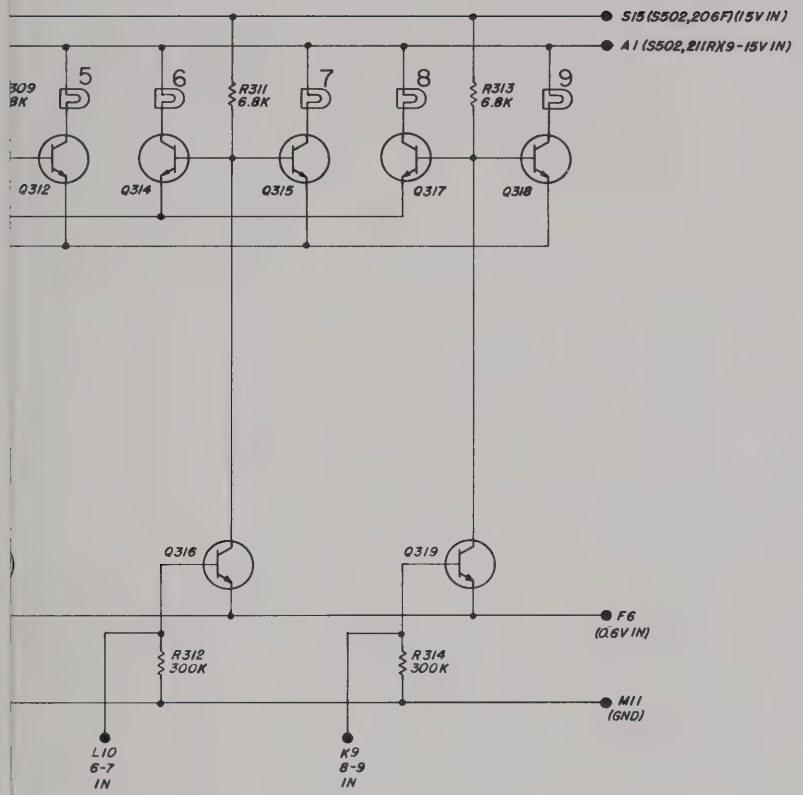
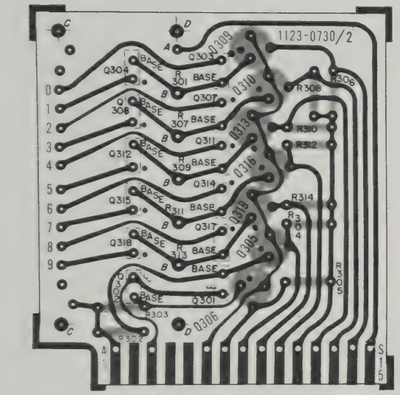
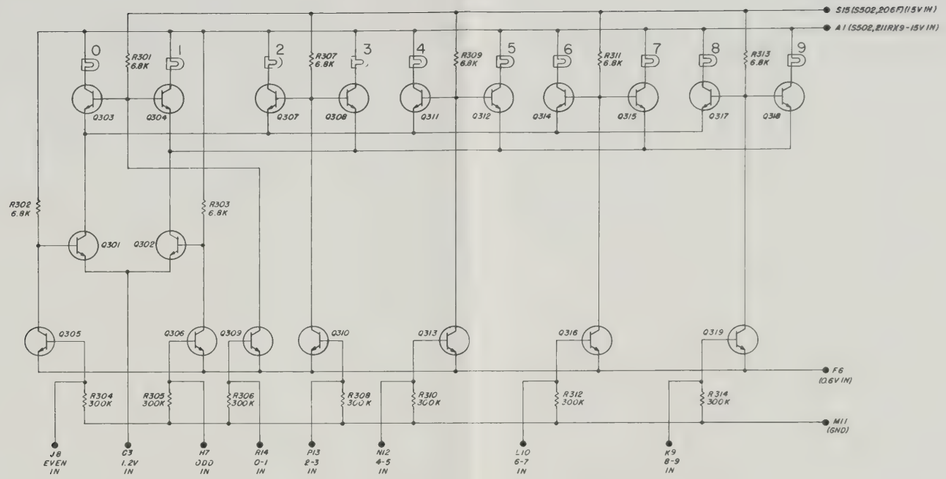
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7. ◯ KNOB CONTROL
8. ◯ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT


S15 (S502,206F) (15V IN)
A1 (S502,211RX9-15V IN)
5
6
7
8
9
R311
6.8K
R313
6.8K
Q312
Q314
Q315
Q317
Q318
Q316
Q319
F6
(0.6V IN)
R312
300K
R314
300K
M11
(GND)
L10
6-7
IN
K9
8-9
IN

DECADE INDICATOR DRIVER

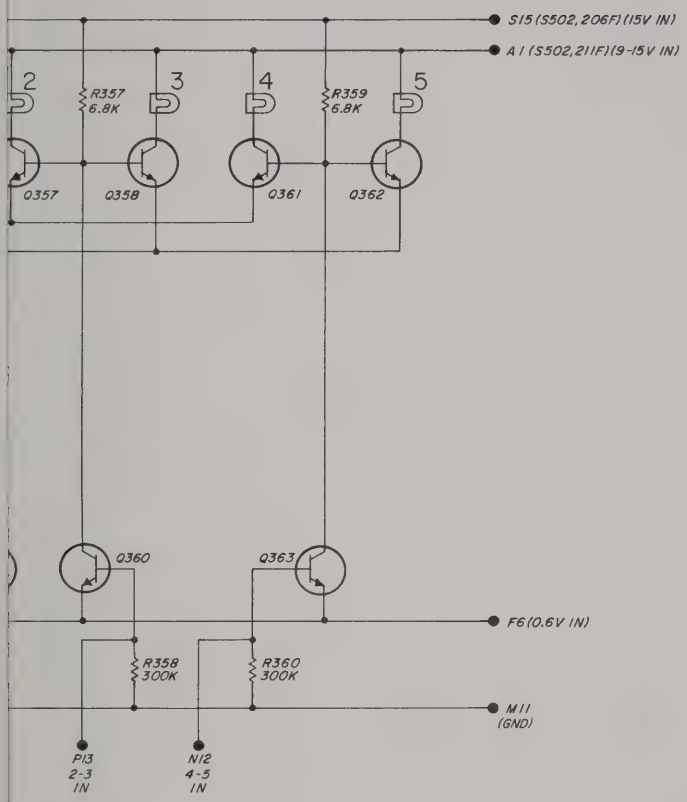




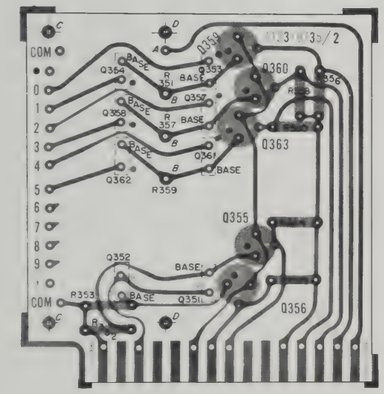
BOTTOM VIEW OF Q301 THRU Q319

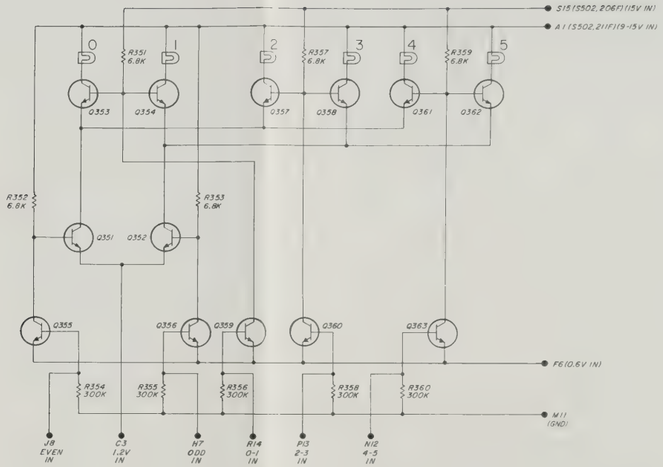
NOTE: UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7. ◯ KNOB CONTROL
8. ⊖ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP - TEST POINT


S15 (S502, 206F) (15V IN)
A1 (S502, 211F) (9-15V IN)
2
3
4
5
R357
6.8K
R359
6.8K
Q357
Q358
Q361
Q362
Q360
Q363
F6 (0.6V IN)
R358
300K
R360
300K
M11
(GND)
P13
2-3
IN
N12
4-5
IN

SCALE OF SIX INDICATOR DRIVER

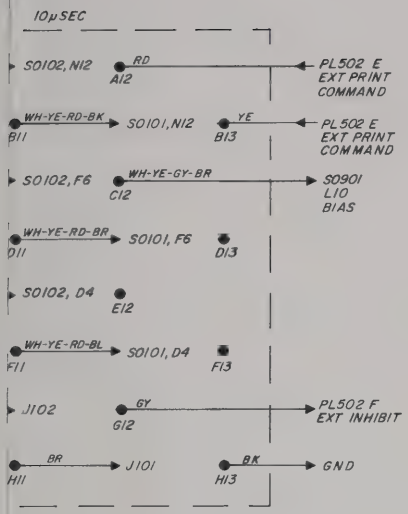


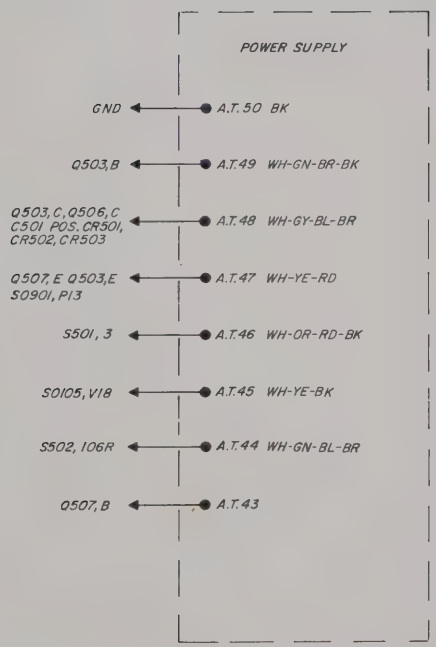


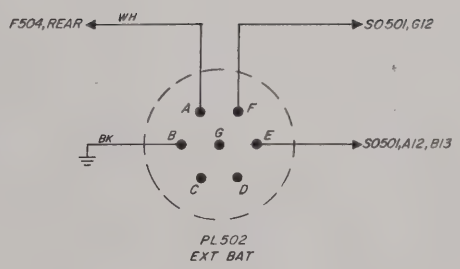
BOTTOM VIEW OF Q351 THRU Q363

NOTE UNLESS SPECIFIED

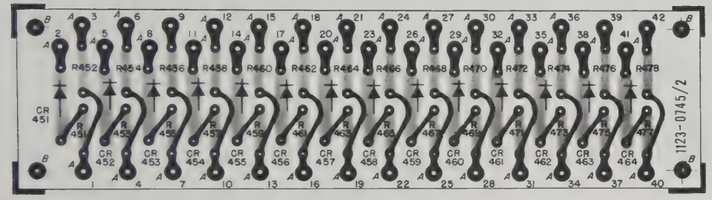
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICROFARADS LESS THAN ONE IN MICROFARADS
7. ⊖ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

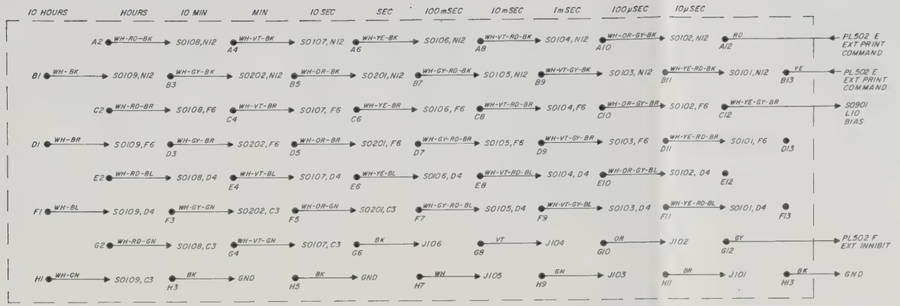

10μ SEC
S0102, N12
A12
RD
PL502 E
EXT PRINT
COMMAND
WH-YE-RD-BK
B11
S0101, N12
B13
YE
PL502 E
EXT PRINT
COMMAND
S0102, F6
C12
WH-YE-GY-BR
S0901
L10
BIAS
WH-YE-RD-BR
D11
S0101, F6
D13
S0102, D4
E12
WH-YE-RD-BL
F11
S0101, D4
F13
J102
G12
GY
PL502 F
EXT INHIBIT
BR
H11
J101
H13
BK
GND


POWER SUPPLY
GND
A.T. 50 BK
Q503, B
A.T. 49 WH-GN-BR-BK
Q503, C, Q506, C
C501 POS. CR501,
CR502, CR503
A.T. 48 WH-GY-BL-BR
Q507, E Q503, E
S0901, P13
A.T. 47 WH-YE-RD
S501, 3
A.T. 46 WH-OR-RD-BK
S0105, V18
A.T. 45 WH-YE-BK
S502, 106R
A.T. 44 WH-GN-BL-BR
Q507, B
A.T. 43

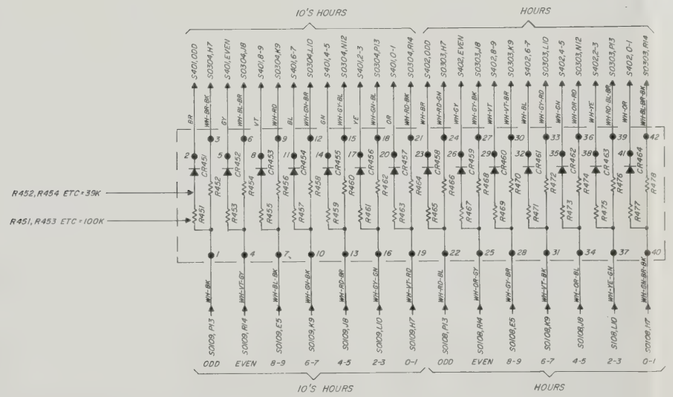

F504, REAR
WH
S0501, G12
A
F
BK
B
G
E
S0501, A12, B13
C
D
PL502
EXT BAT

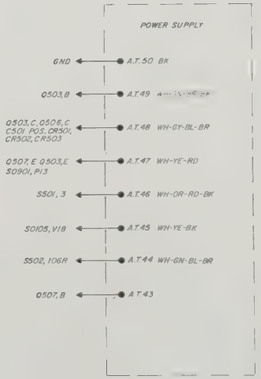
HOURS MATRIX

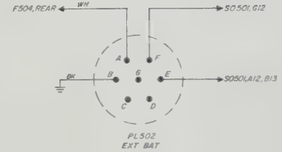




S0501 DIGITAL OUTPUT SOCKET CONNECTIONS




POWER SUPPLY
GND A T.50 BK
Q503,B A T.49
Q503,C, Q506,C C501 POS. CR501, CR502, CR503 A T.48 WH-GY-BL-BR
Q507,E Q503,E S0901, P13 A T.47 WH-YE-RD
S501, 3 A T.46 WH-OR-RD-BK
S0105, V18 A T.45 WH-YE-BK
S502, 106R A T.44 WH-GN-BL-BR
Q507,B A T.43



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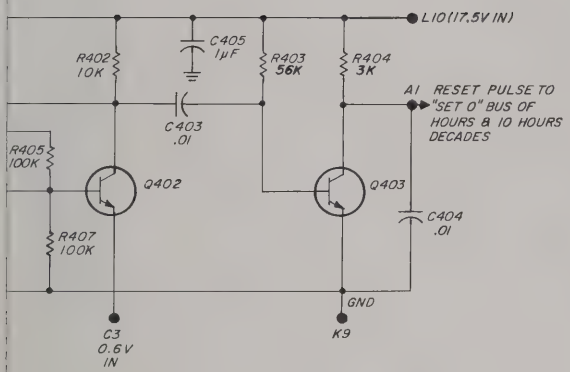
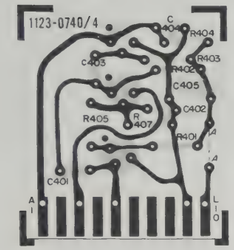
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7. ◯ KNOB CONTROL
8. ◯ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

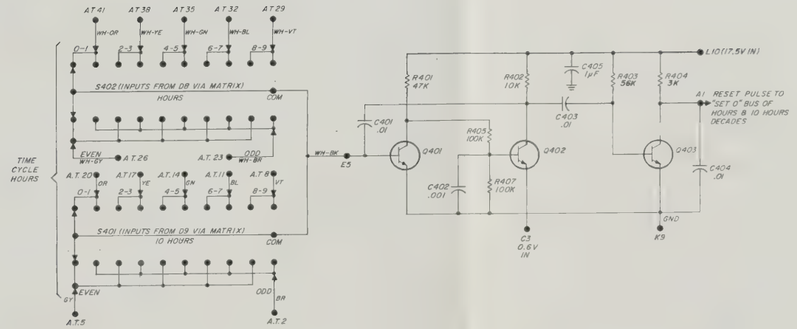
ANCHOR TERMINALS USED: A.T. 1-42


L10 (17.5V IN)
C405
1μF
R402
10K
R403
56K
R404
3K
A1 RESET PULSE TO
"SET 0" BUS OF
HOURS & 10 HOURS
DECADES
C403
.01
R405
100K
Q402
Q403
C404
.01
R407
100K
GND
C3
0.6V
IN
K9

HOURS RESET



CONDITIONS	*INDICATION*	*NOTES*
100-kc drive connected Clock running VISUAL REGISTER switch set to HOUR SET PROGRAM Remove hours reset board.	S0801-E5 approx 0.6 V when HOUR and 10 HOUR indicators match TIME CYCLE setting. over 1 V when HOUR and 10 HOUR indicators do not match TIME CYCLE setting.	Push INITIATE button to advance HOUR and 10 HOUR indicators
100-kc drive connected Clock running hours reset board installed Connect S0104-M11 to S0202-M11	S0801-E5 +0.6 V, −10 V, 60ms	
100-kc drive connected Clock running Connect S0104-M11 to S0202-M11	Q401 collector (case) +10 V, 0, 1 to 2ms	Checks Q401
100-kc drive connected Clock running Connect S0104-M11 to S0202-M11	Q402 collector (case) +15 V, +1 V, 1 to 2ms	Checks Q401 and Q402
100-kc drive connected Clock running Connect S0104-M11 to S0202-M11	Q403 collector (case) or S0401-A1 +6 V, 0, 0.8ms	Checks Q401, Q402, and Q403



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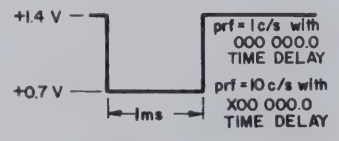
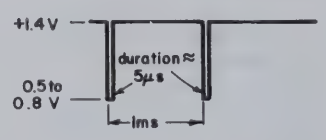
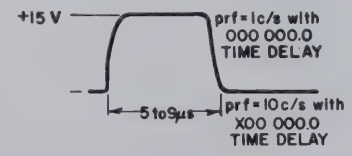
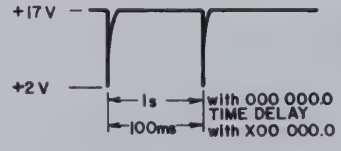
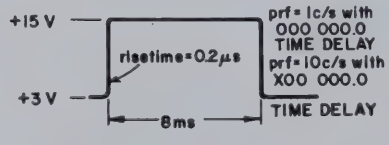
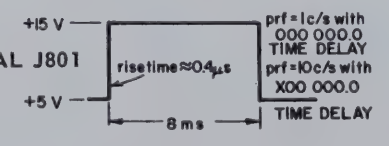
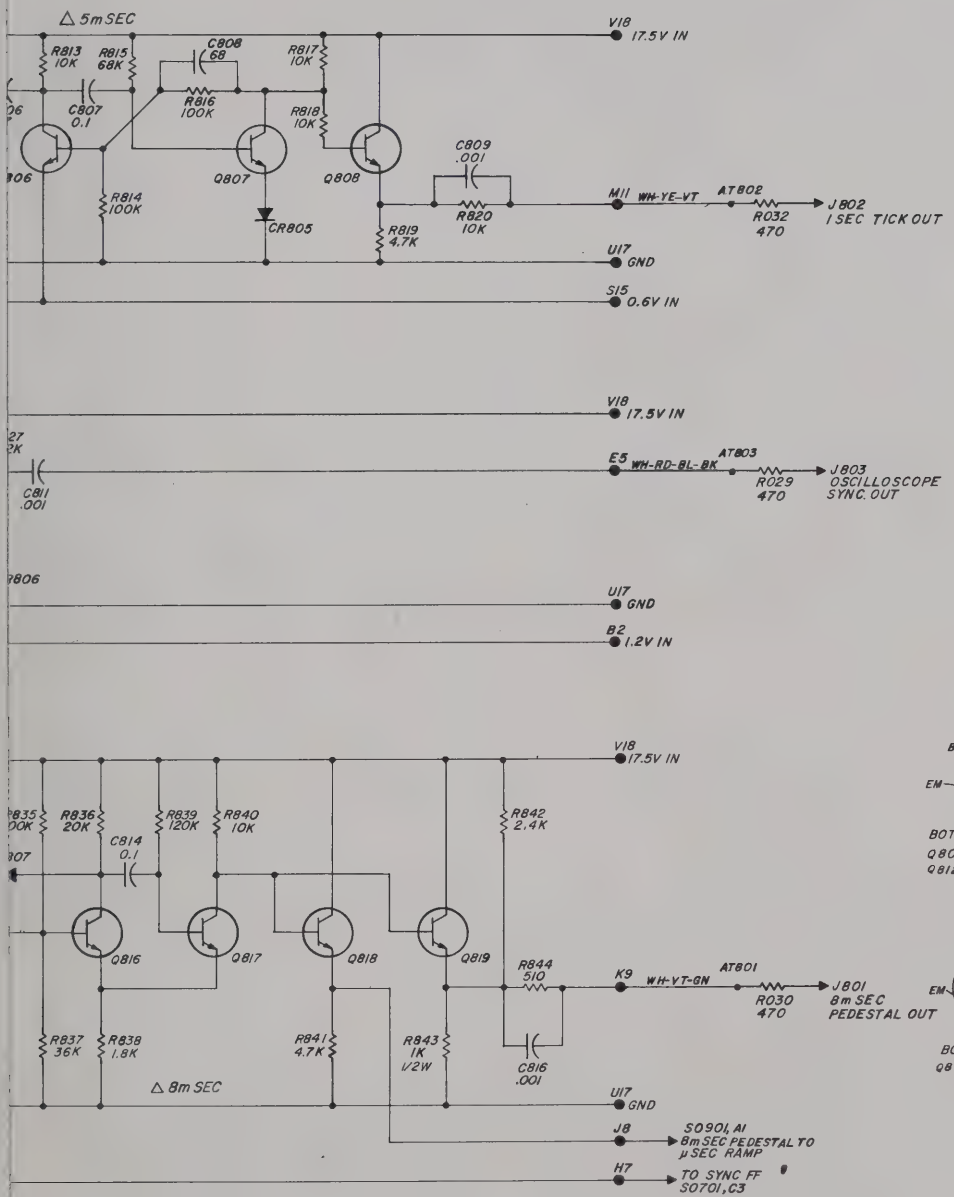
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

GATE CIRCUIT

CONDITION	*INDICATION*	*NOTES*
100-kc drive disconnected gate circuit board removed STOP PROGRAM INITIATE button pushed	SO801-D4 +0.65 to +0.85V SO801-F6 +0.35 to +0.55V	Check saturation voltage of Q102, Q104, Q106, and Q108 in D1 thru D5. Check CR7, R27, and C14. When INITIATE button is pushed in STOP PROGRAM, D1 thru D5 are set to zero.
100-kc drive disconnected Q814 removed Gate circuit board installed STOP PROGRAM INITIATE button pushed	Q812 collector(case) +17V	Checks Q812
100-kc drive disconnected Q814 replaced STOP PROGRAM INITIATE button pushed	*emitter* *base* *collector* Q809 +0.7V +0.7V +14 V Q810 +1.3V +2 V + 1.4V Q811 +0.6V +1.3V + 0.7V Q812 +0.7V +0.5V + 2 V Q813 +1.3V +2 V + 1.4V Q814 +1.4V +2 V + 1.5V Q815 +1.5V 0 +17 V	
100-kc drive connected Clock running	SO801-D4 	Checks signal continuity from D3, D4, and D5 to SO801-D4
100-kc drive connected Clock running	SO801-F6 	Checks signal continuity from D1 and D2 to SO801-F6. Q812 begins to conduct at +1.4V. Pulse amplitude varies with the setting of the 10 and 100μs TIME DELAY switches.
100-kc drive connected Clock running	SO801-E5 or SYNC J803 	Checks Q809, Q810, and Q811.
100-kc drive connected Clock running	SO801-H7 	Checks Q812 through Q815
100-kc drive connected Clock running	SO801-J8 	Checks Q816, Q817, and Q818
100-kc drive connected Clock running	SO80 1-K9 or 8ms PEDESTAL J801 	Checks Q816, Q817, and Q819

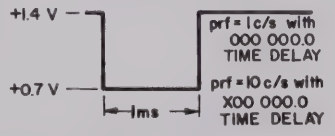
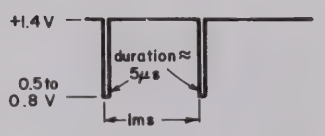
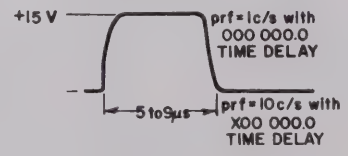
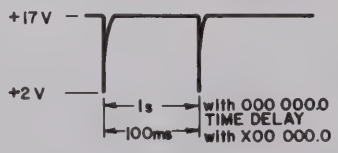
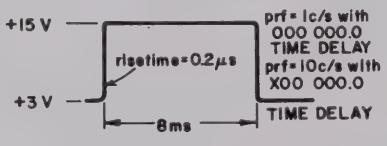
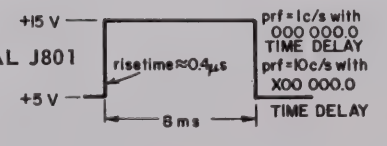


ANCHOR TERMINALS USED: AT801 THRU 803

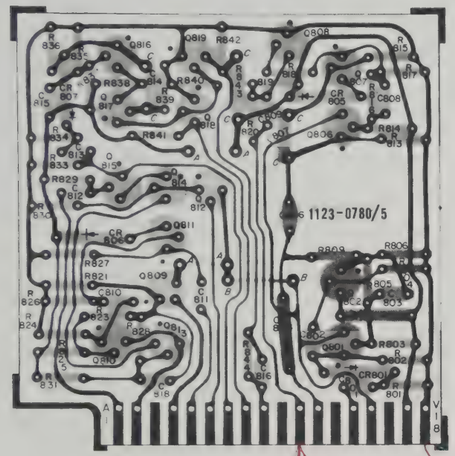
NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

GATE CIRCUIT

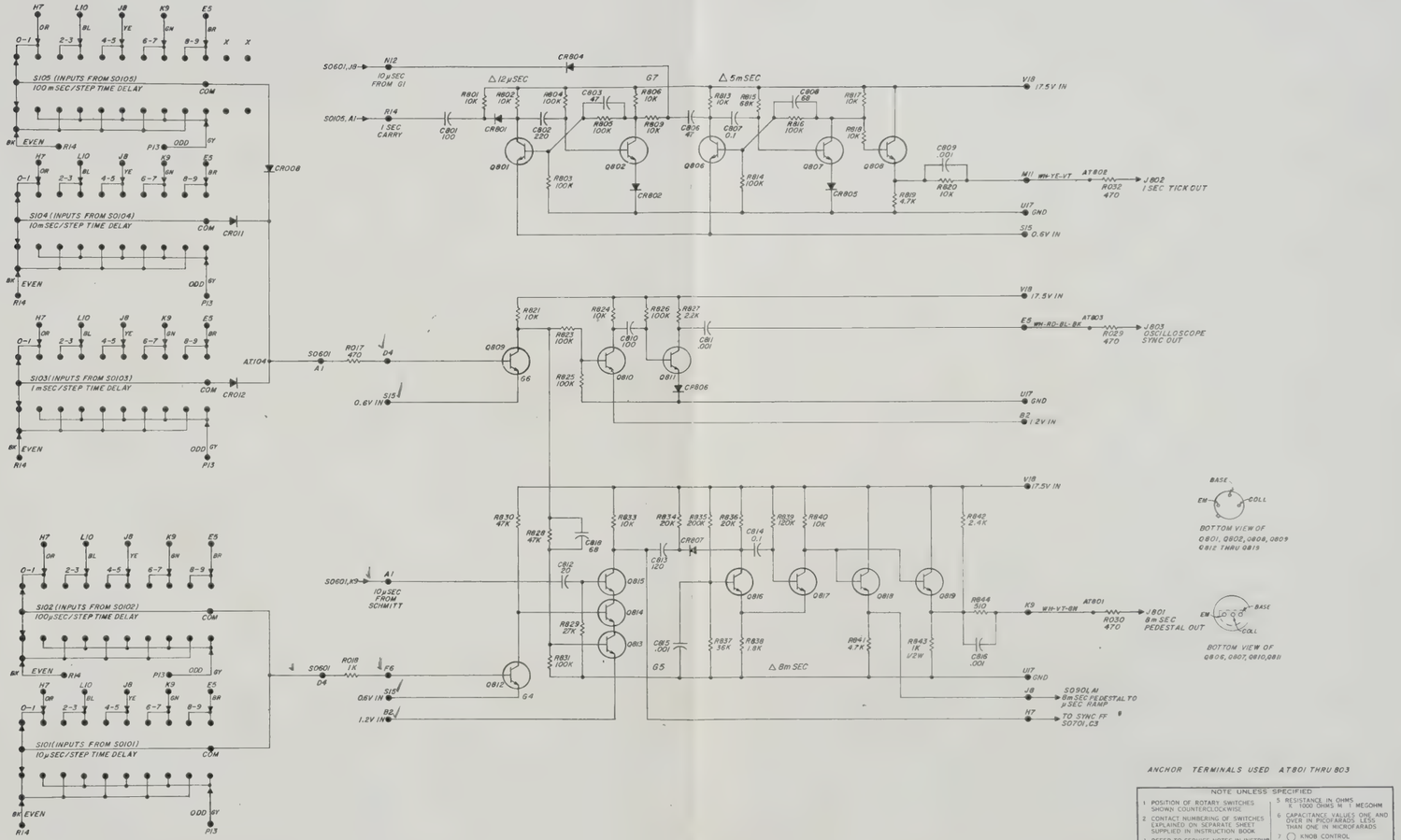
CONDITION	*INDICATION*	*NOTES*
100-kc drive disconnected gate circuit board removed STOP PROGRAM INITIATE button pushed	SO801-D4 +0.65 to +0.85V SO801-F6 +0.35 to +0.55V	Check saturation voltage of Q102, Q104, Q106, and Q108 in D1 thru D5. Check CR7, R27, and C14. When INITIATE button is pushed in STOP PROGRAM, D1 thru D5 are set to zero.
100-kc drive disconnected Q814 removed Gate circuit board installed STOP PROGRAM INITIATE button pushed	Q812 collector(case) +17V	Checks Q812
100-kc drive disconnected Q814 replaced STOP PROGRAM INITIATE button pushed	*emitter* *base* *collector* Q809 +0.7V +0.7V +14 V Q810 +1.3V +2 V + 1.4V Q811 +0.6V +1.3V + 0.7V Q812 +0.7V +0.5V + 2 V Q813 +1.3V +2 V + 1.4V Q814 +1.4V +2 V + 1.5V Q815 +1.5V 0 +17 V	
100-kc drive connected Clock running	SO801-D4 	Checks signal continuity from D3, D4, and D5 to SO801-D4
100-kc drive connected Clock running	SO801-F6 	Checks signal continuity from D1 and D2 to SO801-F6. Q812 begins to conduct at +1.4V. Pulse amplitude varies with the setting of the 10 and 100μs TIME DELAY switches.
100-kc drive connected Clock running	SO801-E5 or SYNC J803 	Checks Q809, Q810, and Q811.
100-kc drive connected Clock running	SO801-H7 	Checks Q812 through Q815
100-kc drive connected Clock running	SO801-J8 	Checks Q816, Q817, and Q818
100-kc drive connected Clock running	SO80 1-K9 or 8ms PEDESTAL J801 	Checks Q816, Q817, and Q819

GATE CIRCUIT



CONDITIONS	INDICATION	NOTES
100-kc drive connected Clock running	SO801-N12 +17V / +5V, falltime = 0.02 µs, 1 s	Checks input circuit
100-kc drive connected Clock running	+17V / +5V, falltime = 0.05 µs, 1 s	Checks 1-s carry
100-kc drive connected SO701-S15 connected to SO801-R14 STOP PROGRAM INITIATE button pushed	CR804 anode +15 V / 0, 12 to 16 µs	Checks Q801 and Q802
100-kc drive connected SO701-S15 disconnected from SO801-R14 Clock running	CR804 anode +14 V / 0, falltime = 0.2 µs, 8 µs	Checks CR804, Q801, and Q802
100-kc drive connected Clock running	SO801-M11 or 1 SEC TICK J802 +14 V / 0, prf = 1 c/s, risetime = 1 µs, 4 to 8 µs	Checks Q806, Q807, and Q808

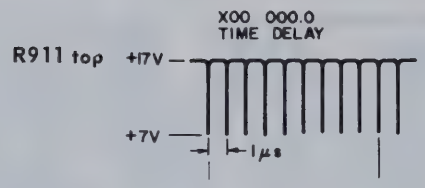
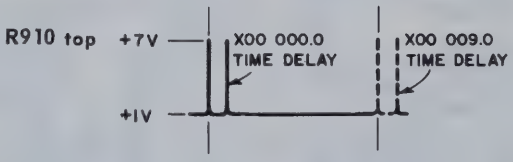
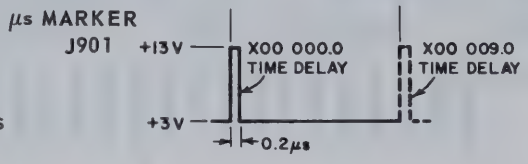
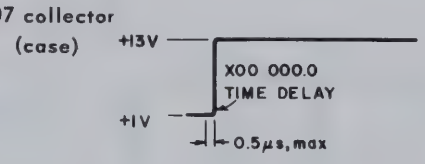
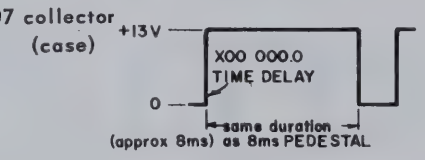
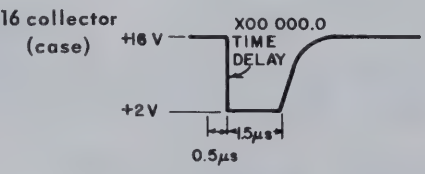
1123-67

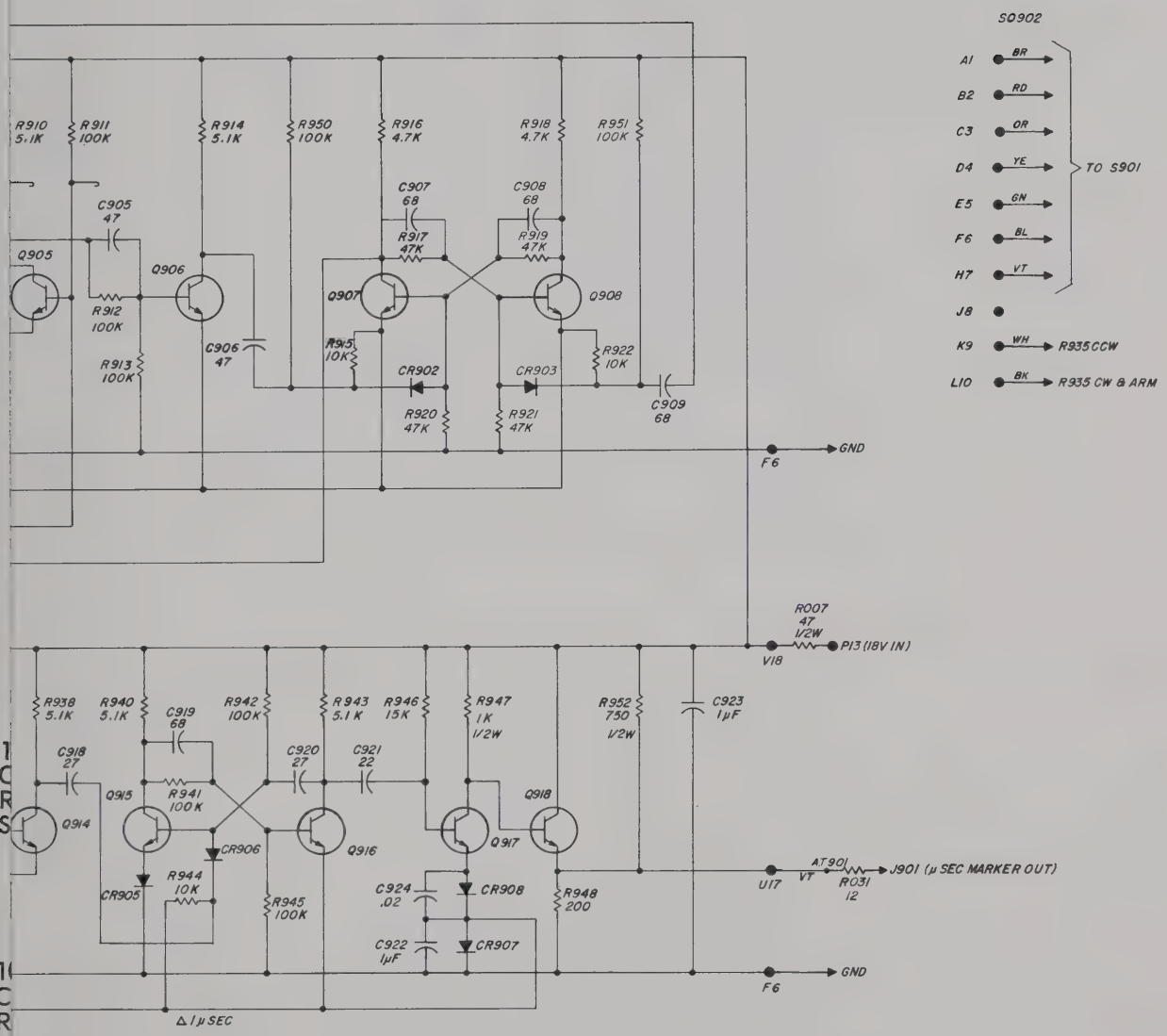

SI05 (INPUTS FROM SO105) 100 m SEC/STEP TIME DELAY
SI04 (INPUTS FROM SO104) 10m SEC/STEP TIME DELAY
SI03 (INPUTS FROM SO103) 1m SEC/STEP TIME DELAY
SI02 (INPUTS FROM SO102) 100µSEC/STEP TIME DELAY
SI01 (INPUTS FROM SO101) 10µSEC/STEP TIME DELAY
SO601, I8
SO105, A1
SO601, K9
SO601 A1
SO601 D4
△12µSEC
△5m SEC
△8m SEC
J801 8m SEC PEDESTAL OUT
J802 1 SEC TICK OUT
J803 OSCILLOSCOPE SYNC OUT
SO90I A1 8m SEC PEDESTAL TO µSEC RAMP
TO SYNC FF SO701, C3
ANCHOR TERMINALS USED AT801 THRU 803
BOTTOM VIEW OF Q801, Q802, Q808, Q809 Q812 THRU Q819
BOTTOM VIEW OF Q805, Q807, Q810, Q811

NOTE: UNLESS SPECIFIED

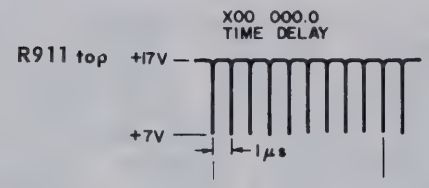
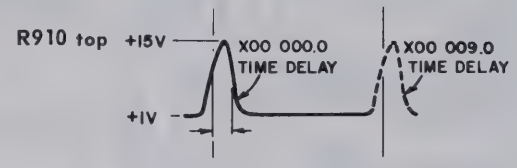
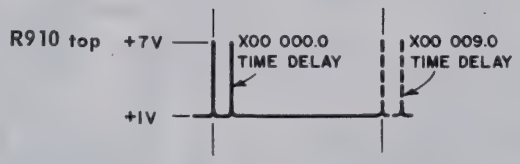
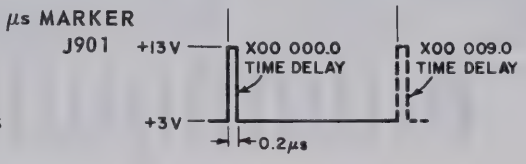
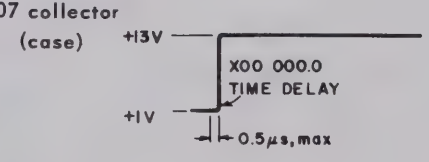
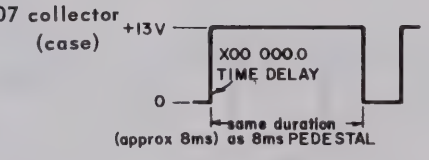
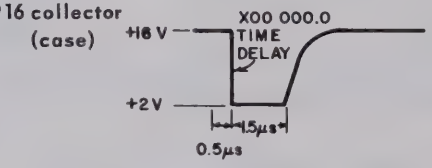
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN MICROFARADS LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

DELAY GENERATOR

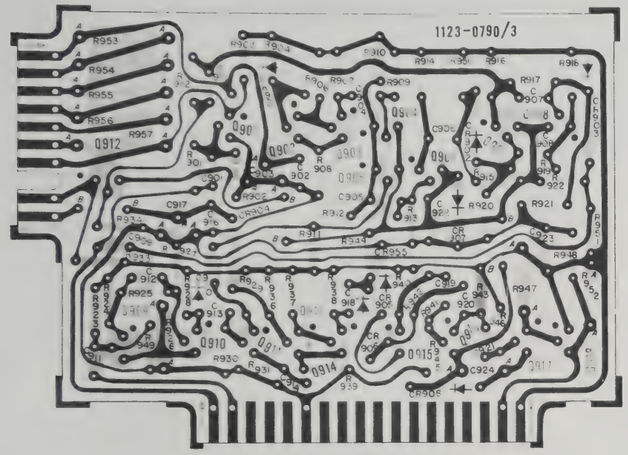
CONDITIONS	*INDICATION*	*NOTES*
100-kc and 1-Mc drives connected Clock running Remove D4 Remove Q905 Scope: + external trigger from 8ms PEDESTAL J801		Checks Q909, Q910, and Q911
100-kc and 1-Mc drives connected Clock running Remove D4 Remove Q905 Scope: + external trigger from 8ms PEDESTAL J801		Checks Q901 thru Q904. The μs TIME DELAY switch should move the pulse in 1-μs increments.
100-kc and 1-Mc drives connected. Clock running Remove D4 Replace Q905 Scope: + external trigger from 8ms PEDESTAL J801.		Checks Q905. The μs TIME DELAY switch should move the pulse in 1-μs increments.
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801.		The μs TIME DELAY switch should move the pulse in 1-μs increments
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801		The μs TIME DELAY switch should move the pulse in 1-μs increments.
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801.		
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801		Checks Q912 through Q916. For access to Q916 collector, remove delay generator board, attach clip lead to Q916 case, and replace board. The 1-μs TIME DELAY switch should move the pulse in 1-μs increments.

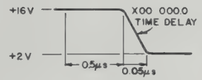
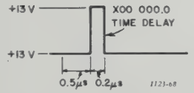

S0902
A1 BR
B2 RD
C3 OR
D4 YE
E5 GN
F6 BL
H7 VT
TO S901
J8
K9 WH R935CCW
L10 BK R935 CW & ARM
R910 5.1K
R911 100K
R914 5.1K
R950 100K
R916 4.7K
R918 4.7K
R951 100K
C905 47
C907 68
C908 68
R917 47K
R919 47K
Q905
Q906
Q907
Q908
R912 100K
R913 100K
C906 47
R915 10K
R922 10K
CR902
CR903
R920 47K
R921 47K
C909 68
GND
F6
R007 47 1/2W
P13 (18V IN)
V18
R938 5.1K
R940 5.1K
C919 68
R942 100K
R943 5.1K
R946 15K
R947 1K 1/2W
R952 750 1/2W
C923 1μF
C918 27
C920 27
C921 22
Q915
Q914
R941 100K
Q916
Q917
Q918
CR906
CR905
R944 10K
R945 100K
C924 .02
CR908
C922 1μF
CR907
R948 200
AT901
VT
U17
R031 12
J901 (μ SEC MARKER OUT)
GND
F6
Δ 1μ SEC

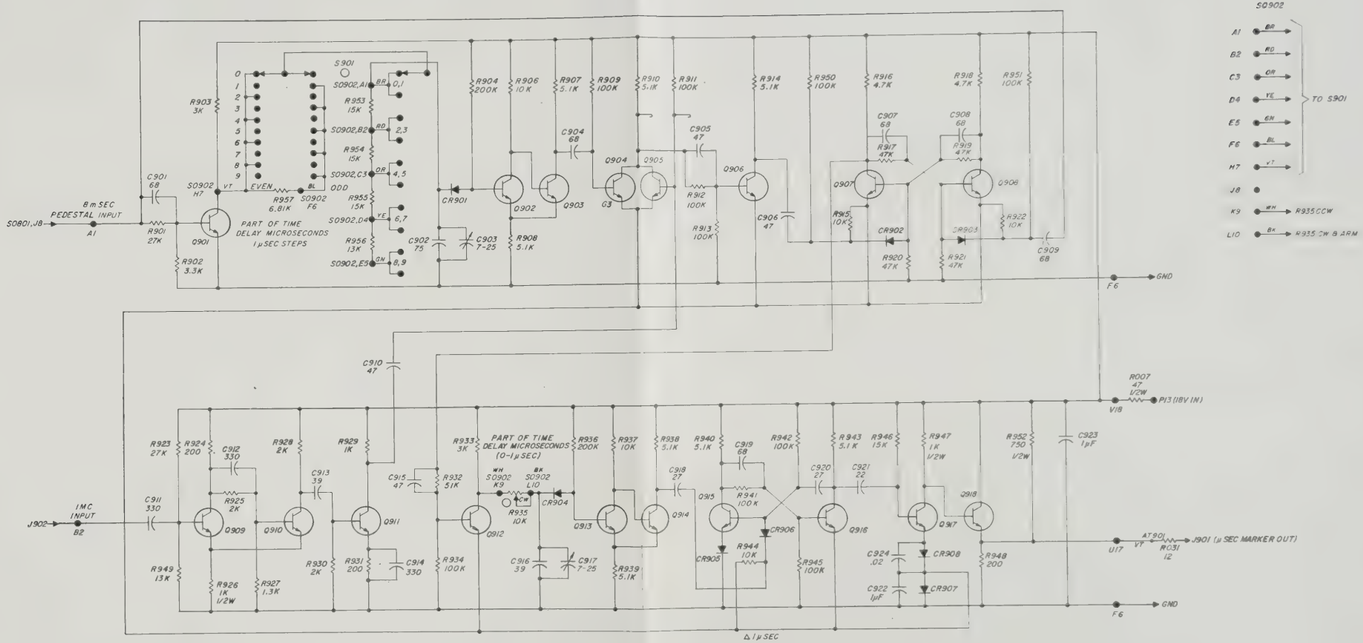
DELAY GENERATOR

CONDITIONS	*INDICATION*	*NOTES*
100-kc and 1-Mc drives connected Clock running Remove D4 Remove Q905 Scope: + external trigger from 8ms PEDESTAL J801		Checks Q909, Q910, and Q911
100-kc and 1-Mc drives connected Clock running Remove D4 Remove Q905 Scope: + external trigger from 8ms PEDESTAL J801		Checks Q901 thru Q904. The μs TIME DELAY switch should move the pulse in 1-μs increments.
100-kc and 1-Mc drives connected. Clock running Remove D4 Replace Q905 Scope: + external trigger from 8ms PEDESTAL J801.		Checks Q905. The μs TIME DELAY switch should move the pulse in 1-μs increments.
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801.		The μs TIME DELAY switch should move the pulse in 1-μs increments
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801		The μs TIME DELAY switch should move the pulse in 1-μs increments.
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801.		
100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801		Checks Q912 through Q916. For access to Q916 collector, remove delay generator board, attach clip lead to Q916 case, and replace board. The 1-μs TIME DELAY switch should move the pulse in 1-μs increments.

DELAY GENERATOR



CONDITIONS	INDICATION	NOTES
Q916 collector (case) 100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801.		Checks Q912 thru Q916. For access to Q916 collector, remove delay generator board, attach clip lead to Q916 case, and replace board. The 1 μs TIME DELAY switch should move the pulse in 1-μs increments.
μs MARKER J901 100-kc and 1-Mc drives connected Clock running Remove D4 Scope: + external trigger from 8ms PEDESTAL J801.		Checks Q917 and Q918. The .1μs TIME DELAY dial should move the pulse 0.1 μs every major dial division.



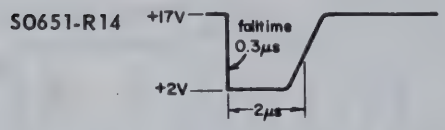
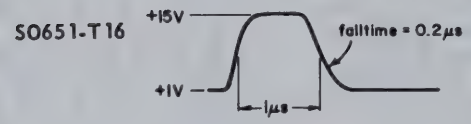
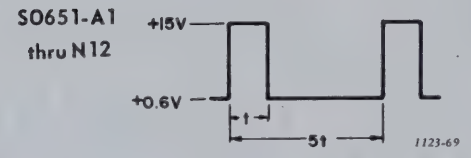
ANCHOR TERMINALS USED: AT 901

BOTTOM VIEW OF Q901 THRU Q918

NOTE UNLESS SPECIFIED

1 POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2 CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3 REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4 RESISTORS 1/4 WATT
5 RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6 CAPACITANCE VALUES ONE AND OVER IN PICOFARADS LESS THAN ONE IN MICROFARADS
7 ○ KNOB CONTROL
8 ○ SCREWDRIVER CONTROL
9 AT ANCHOR TERMINAL
10 TP TEST POINT

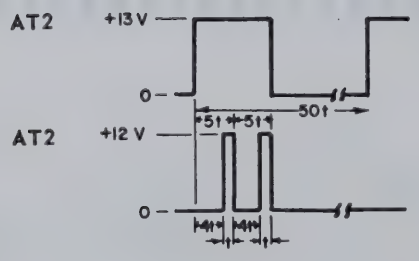
INHIBIT CIRCUIT

CONDITIONS	*INDICATION*	*NOTES*
100-kc drive applied Clock running	SO651-R14 	Checks G1, Q667, and Q668
100-kc drive applied Clock running	SO651-T16 	Checks G1, Q667, and Q668
100-kc drive applied Clock running	SO651-A1 thru N12 	Checks Q651 thru Q662 and outputs of D1 thru D6

SO651 –

	A1 B2	*C3 D4*	*E5 F6*	*J 8 H7*	*K9 L10*	*M11 N12*
t	20 μs	200 μs	2 ms	20 ms	200 ms	2 s
5t	100 μs	1 ms	10 ms	100 ms	1 s	10 s

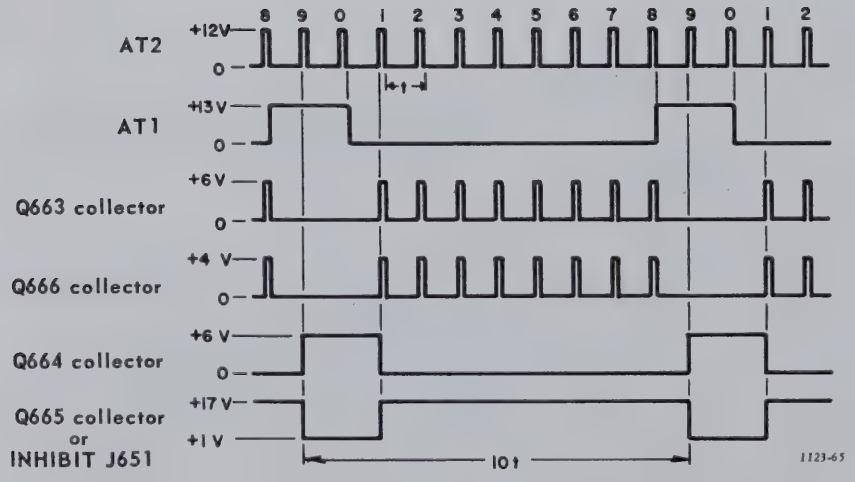
100-kc drive applied
Clock running
Scope: + external trigger from AT1.



INHIBIT RATE

	10 kc/s	*1 kc/s*	*100 c/s*	*10 c/s*	*standard 1 c/s*
t	2 μs	20 μs	200 μs	2 ms	20 ms
4t	8 μs	80 μs	800 μs	8 ms	80 ms
5t	10 μs	100 μs	1 ms	10 ms	100 ms
50t	100 μs	1 ms	10 ms	100 ms	1 s

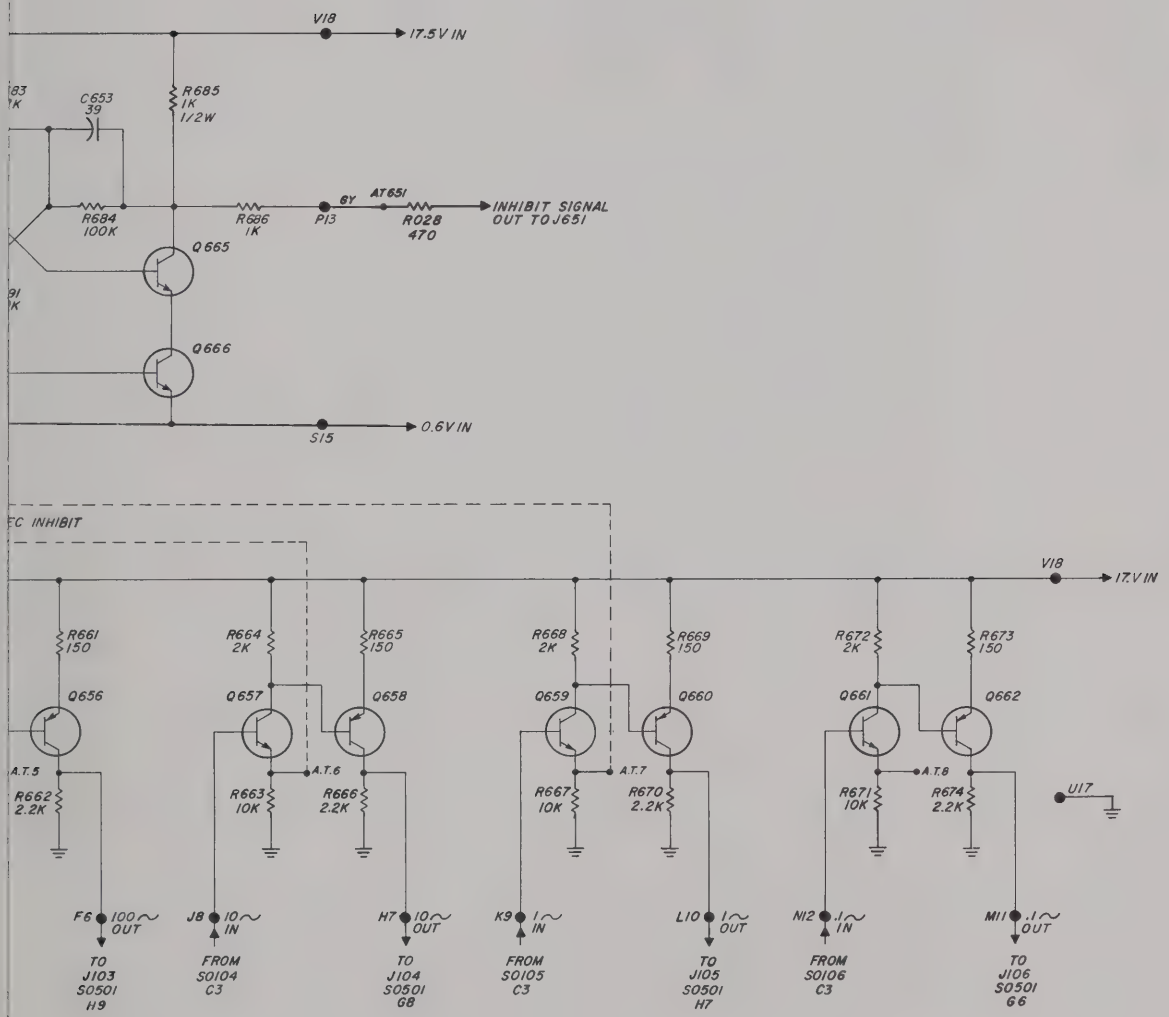
TIMING



INHIBIT output at J651 has same prf as input to AT1.

INHIBIT RATE

	10 kc/s	*1 kc/s*	*100 c/s*	*10 c/s*	*standard 1 c/s*
t	10 μs	100 μs	1 ms	10 ms	100 ms
10t	100 μs	1 ms	10 ms	100 ms	1 s

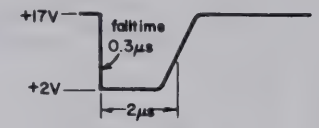

V18
17.5V IN
C653
39
R685
1K
1/2W
R684
100K
R686
1K
P13
AT651
R028
470
INHIBIT SIGNAL
OUT TO J651
Q665
Q666
S15
0.6V IN
EC INHIBIT
V18
17.V IN
R661
150
R664
2K
R665
150
R668
2K
R669
150
R672
2K
R673
150
Q656
Q657
Q658
Q659
Q660
Q661
Q662
A.T.5
A.T.6
A.T.7
A.T.8
R662
2.2K
R663
10K
R666
2.2K
R667
10K
R670
2.2K
R671
10K
R674
2.2K
U17
F6
100~
OUT
TO
J103
S0501
H9
J8
10~
IN
FROM
S0104
C3
H7
10~
OUT
TO
J104
S0501
G8
K9
1~
IN
FROM
S0105
C3
L10
1~
OUT
TO
J105
S0501
H7
N12
.1~
IN
FROM
S0106
C3
M11
.1~
OUT
TO
J106
S0501
G6

INHIBIT CIRCUIT

CONDITIONS | *INDICATION* | *NOTES*

100-kc drive applied
Clock running

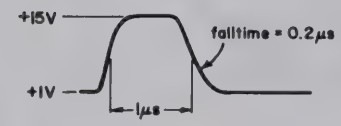
SO651-R14



Checks G1, Q667, and Q668

100-kc drive applied
Clock running

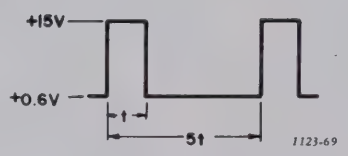
SO651-T16



Checks G1, Q667, and Q668

100-kc drive applied
Clock running

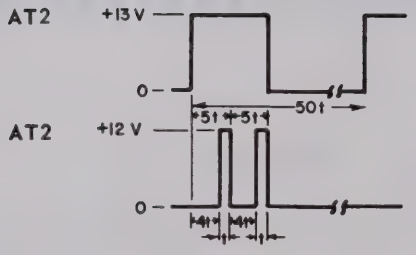
SO651-A1 thru N12



Checks Q651 thru Q662 and outputs of D1 thru D6

	SO651 – A1 B2	C3 D4	E5 F6	J 8 H7	K9 L10	M11 N12
t	20 μs	200 μs	2 ms	20 ms	200 ms	2 s
5t	100 μs	1 ms	10 ms	100 ms	1 s	10 s

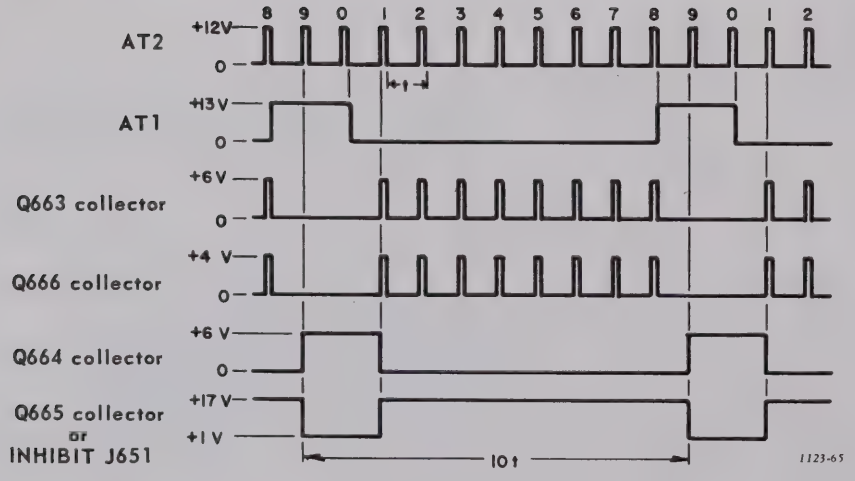
100-kc drive applied
Clock running
Scope: + external trigger from AT1.



INHIBIT RATE

	10 kc/s	*1 kc/s*	*100 c/s*	*10 c/s*	*standard 1 c/s*
t	2 μs	20 μs	200 μs	2 ms	20 ms
4t	8 μs	80 μs	800 μs	8 ms	80 ms
5t	10 μs	100 μs	1 ms	10 ms	100 ms
50t	100 μs	1 ms	10 ms	100 ms	1 s

TIMING

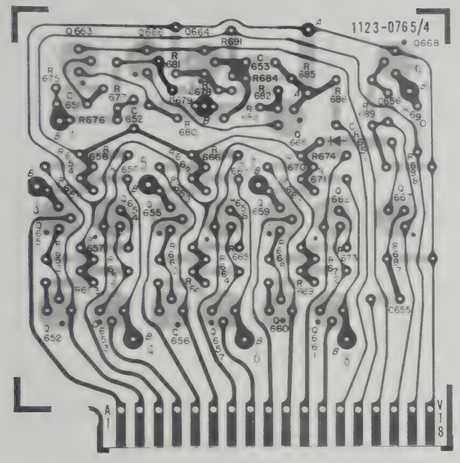


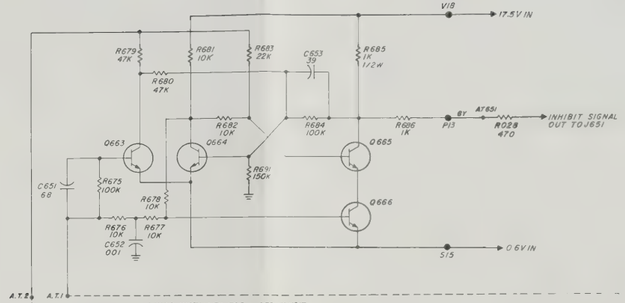
INHIBIT output at J651 has same prf as input to AT1.

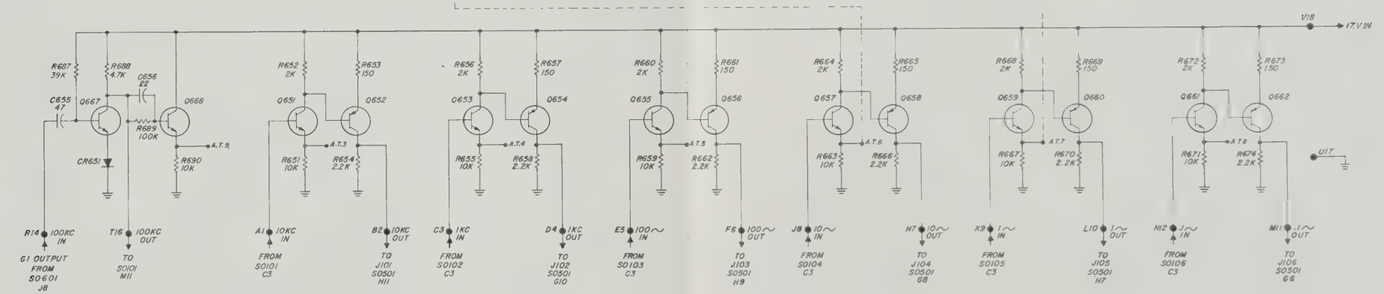
INHIBIT RATE

	10 kc/s	*1 kc/s*	*100 c/s*	*10 c/s*	*standard 1 c/s*
t	10 μs	100 μs	1 ms	10 ms	100 ms
10t	100 μs	1 ms	10 ms	100 ms	1 s

INHIBIT CIRCUIT





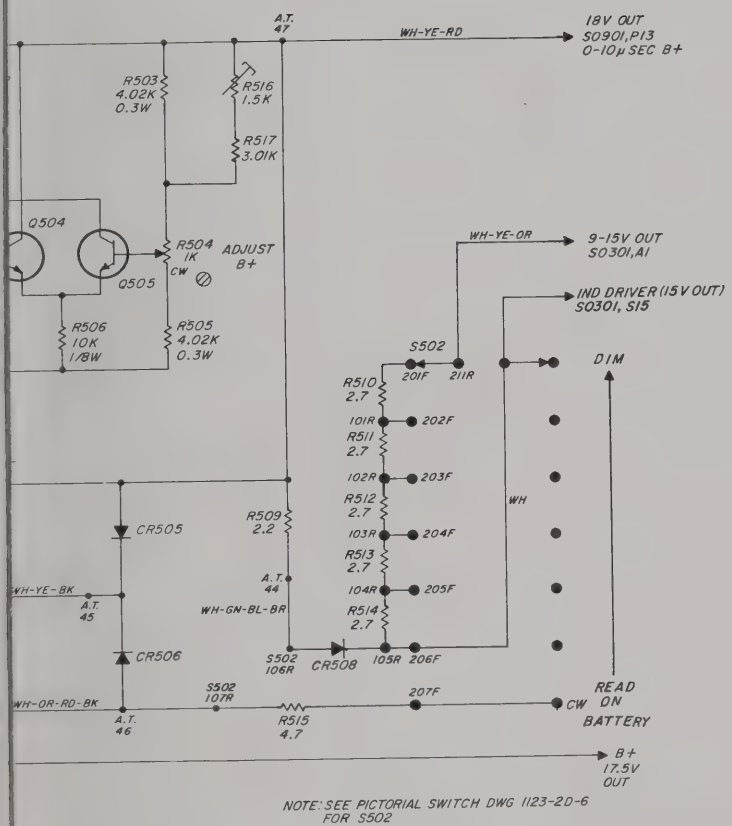


NOTE UNLESS SPECIFIED

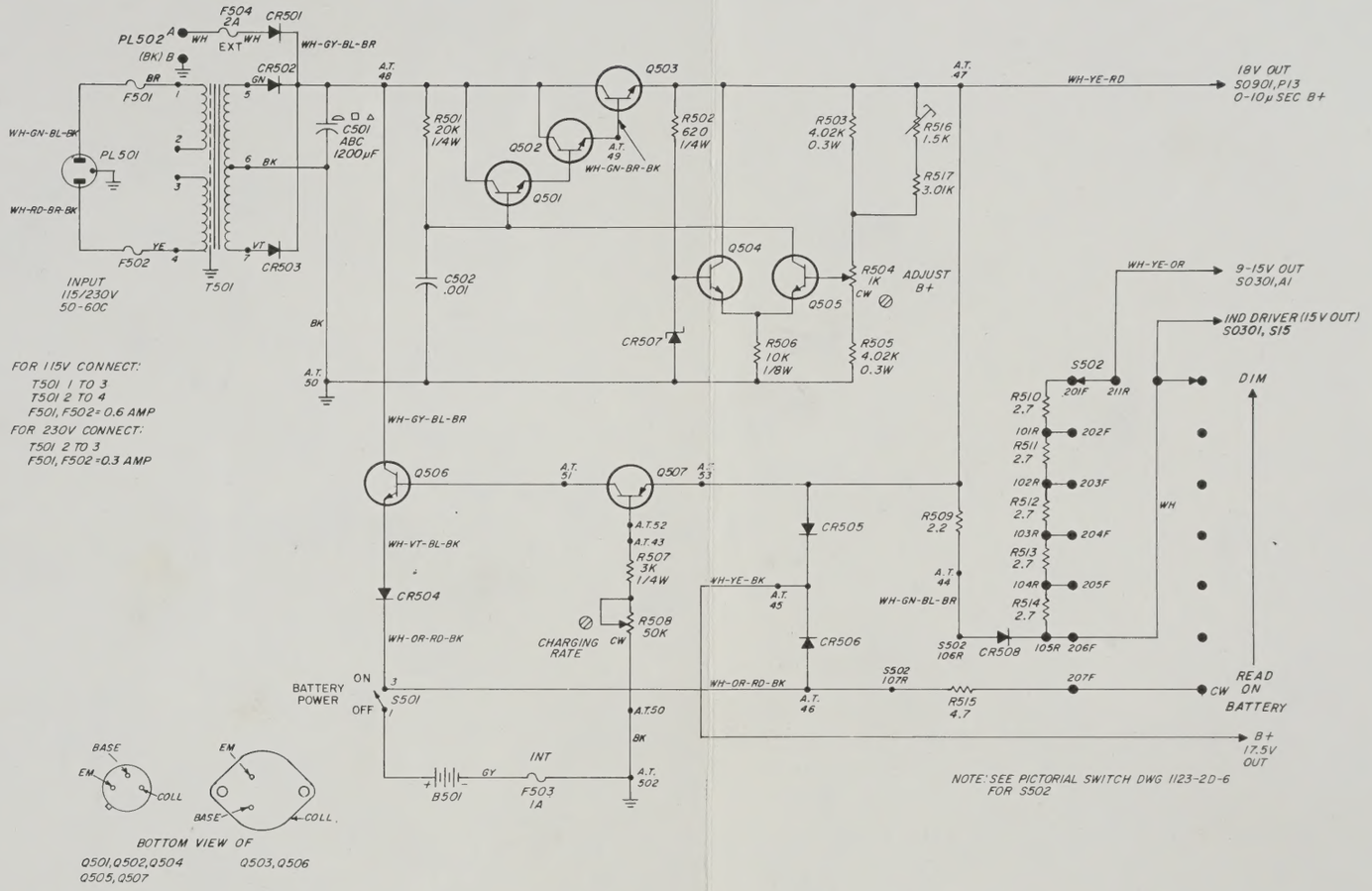
1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM
4. RESISTORS 1/4 WATT
5. RESISTANCE IN OHMS K = 1000 OHMS M = 1 MEGOHM
6. CAPACITANCE VALUES ONE AND LESS THAN ONE IN MICROFARADS
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

BOTTOM VIEW OF Q651 THRU Q668

ANCHOR TERMINALS USED: A.T.1 THRU 9 & 651



NOTE: SEE PICTORIAL SWITCH DWG 1123-2D-6 FOR S502



FOR 115V CONNECT:
T501 1 TO 3
T501 2 TO 4
F501, F502 = 0.6 AMP
FOR 230V CONNECT:
T501 2 TO 3
F501, F502 = 0.3 AMP

NOTE: SEE PICTORIAL SWITCH DWG 1123-2D-6 FOR S502

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 2 WATT.
5. RESISTANCE IN OHMS K 1000 OHMS M 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT ANCHOR TERMINAL
10. TP TEST POINT

ANCHOR TERMINALS USED: A.T. 43 THRU 53, 502

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